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THE COST OF CLEAN WATER. VOLUME III. INDUSTRIAL WASTE PROFILES NO. 6. CANNED AND FROZEN FRUITS AND VEGETABLES

Federal Water Pollution Control Administration
Washington, D. C.

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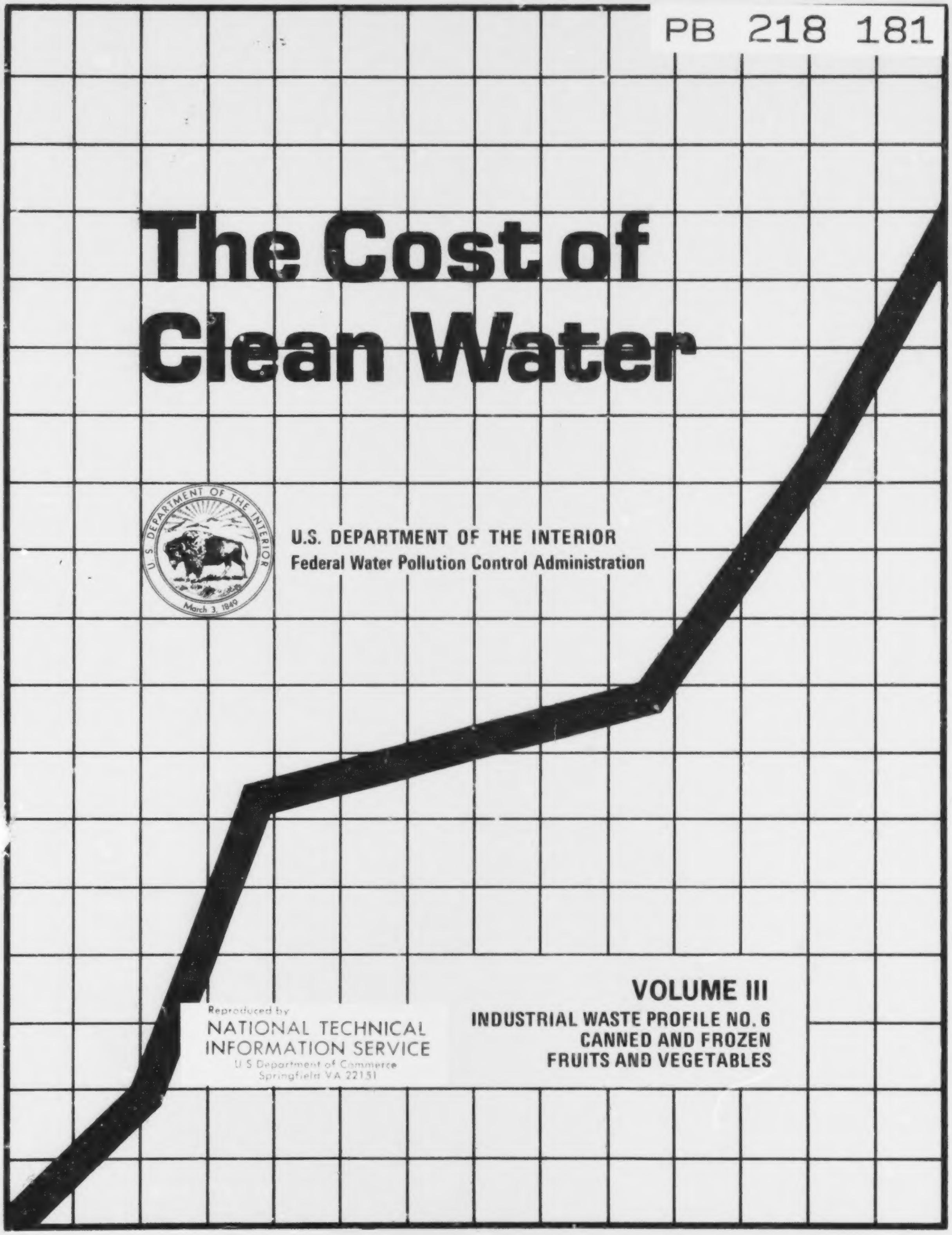

The Cost of Clean Water

March 3, 1849

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

VOLUME III

INDUSTRIAL WASTE PROFILE NO. 6
CANNED AND FROZEN FRUITS AND VEGETABLES

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THE COST OF CLEAN WATER

Volume III

Industrial Waste Profiles
No. 6 - Canned and Frozen Fruits and Vegetables

U. S. Department of the Interior
Federal Water Pollution Control Administration

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I

PREFACE

The Industrial Waste Profiles are part of the National Requirements and Cost Estimate Study required by the Federal Water Pollution Control Act as amended. The Act requires a comprehensive analysis of the requirement and costs of treating municipal and industrial wastes and other effluents to attain prescribed water quality standards.

The Industrial Waste Profiles were established to describe the source and quantity of pollutants produced by each of the ten industries studied. The profiles were designed to provide industry and government with information on the costs and alternatives involved in dealing effectively with the industrial water pollution problem. They include descriptions of the costs and effectiveness of alternative methods of reducing liquid wastes by changing processing methods, by intensifying use of various treatment methods, and by increasing utilization of wastes in by-products or water reuse in processing. They also describe past and projected changes in processing and treatment methods.

The information provided by the profiles cannot possibly reflect the cost or wasteload situation for a given plant. However, it is hoped that the profiles, by providing a generalized framework for analyzing individual plant situations, will stimulate industry's efforts to find more efficient ways to reduce wastes than are generally practiced today.

James M. Quigley
Commissioner
Federal Water Pollution Control Administration

INDUSTRIAL WASTE PROFILE

CANNED AND FROZEN FRUITS AND VEGETABLES

Prepared for F.W.P.C.A.

DI-
FWPCA Contract Number 14-12-101
June 30, 1967

Federal Water Pollution Control Administration
September 1967

III

SCOPE

The scope of material included in this profile report conforms to the requirements of the United States Department of the Interior Federal Water Pollution Control Administration Contract Number 14-12-101. Within the available 90 day study period, engineering and economic data has been critically studied by means of a total industry approach. The relationship of the product to the alternative sub-system manufacturing processes has been reviewed in the field and office with responsible industry representatives. The cognizant professional associations and industrial experts have presented their data and viewpoint, and have reviewed our draft information. Key plant managers have cooperated in allowing limited spot checks of their plant subprocesses and waste sampling. The literature has, of course, been completely reviewed.

Because of the wide diversity of plants and processes, we have attempted to achieve a comprehensive overview of the approximate subprocesses. We have evaluated the total relationship of products produced, waste pollution load, economics involved, and long term environmental quality factors.

INDUSTRIAL WASTE PROFILE

CANNED AND FROZEN FRUITS AND VEGETABLES

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CANNED AND FROZEN FRUITS AND VEGETABLES

SUMMARY

This industry is one of the most important to the people of the United States because 1) its total annual retail value today exceeds $5 billion for canned food and $3 billion for frozen food; 2) it utilizes great quantities of water - in 1964 alone the 'pack' of 944 million equivalent cases of canned and frozen fruits and vegetables required 76 billion gal of water; and 3) the raw materials are grown almost exclusively within our country, are processed here, and fulfill almost all of our domestic consumption needs.

The production of canned fruits and vegetables has increased about 35 percent in the last 15-16 years. Frozen fruit and vegetable production increased 300 percent during the same period, largely due to the expanded market for frozen vegetables. There are many reasons for this change. The most important are public acceptance of frozen products and more efficient and economical methods of keeping the products frozen during transport and marketing.

It is an understatement to describe the industry as diversified. Literally dozens of entirely different raw and partially prepared products are processed in more than 3150 plants. Of these, about 2000 can or freeze fruits and vegetables. Each plant may produce a variety of canned or frozen products. For the purposes of this report production has been subdivided as follows:

1. Canned fruits and vegetables
2. Frozen fruits and vegetables

As shown in the Process Flow Chart accompanying this study, the Initial Preparation, common to all raw products, involves pre-cleaning, size grading, and sorting. The purpose of these initial processes is to remove unwanted and undesirable material from the food before it undergoes processing. Wastes from this operation often include soil, sand, stones, insecticides, dried plant juices, vegetation, insects, and other residues. These impurities are generally soaked and/or spray-rinsed off the raw product, although a limited amount of air cleaning has been used. The amount of impurities obtained in this process depends upon the type of harvesting (hand or machine-picked) and the degree of cleaning in the production line. The current trends are toward mechanically-picked raw products which contain more soil and other foreign matter, and higher product specifications calling for more complete cleaning. Both trends are additive and encourage

higher wastewater volumes and pollutional loads. Size grading is usually done with screens, belts or other separators. Sorting is usually a hand operation and primarily affects the quantity of solid wastes to be removed from the premises.

The following processes are included in initial preparation: trimming, coring and pitting, cutting, peeling, inspection, and grading. However, not all raw products are processed by each of the steps.

While trimming is mainly a hand operation, some liquid and solid wastes originate from this operation. Coring and pitting,primarily fruits, is generally a mechanical process resulting in a solid residue usually disposed of on land. The cutting operation emits some liquid waste primarily from product juices and equipment wash water. Peeling of the skin can be done by hand, steam,machines, or chemicals. The last two methods are most common and produce a considerable volume of wastewater and high loads of BOD. A major percentage of the wasteload is derived from chemical peeling operations which are used by plants processing peaches, tomatoes, and other products requiring skinning. The raw products are immersed for certain periods of time in hot lye solutions which literally dissolve the skin of the fruit. The lye solution is usually piped to storage containers for reuse. The peeled raw product is rinsed with water upon emerging from the lye bath. The waste discharged from the lye peel rinse is highly alkaline, hot, highly mineralized, and contains a considerable amount of dissolved organic matter. In many canneries and frozen food plants this one waste represents the largest single source of BOD and suspended solids. After grading and inspection, the final step in Initial Preparation, is transportation, usually by belt conveyors or flume, to the Converted Product Handling processes. Water fluming requires less maintenance, is less costly to operate, and serves to protect and rinse the product during transportation. However, if flume water is discharged without extended reuse, it represents a large volume and percentage of total wastewater. It may contain a significant amount of total plant BOD and suspended solids.

The first eight processes, plus plant clean-up from these operations, often contribute about 50 percent of the total plant wastewater volume, a major portion of the plant BOD, and, except in isolated cases, virtually all of the suspended solids.

Converted Product Handling of canned fruits and vegetables involves some or all of the following processes: blanching, mixing and adding syrups and brine solutions, pulping, straining, cooking in vats, can filling, exhausting and sealing, thermo processing, can cooling, and storage. In addition, the equipment and floors of this portion of the cannery are usually cleaned either continuously, at the end of each shift, or at the end of each day.

The blanching process is of major importance. The blanching operation exposes the product (mostly green vegetables) to steam or hot water for a short period of time. This retards the degradation of the organic matter by its enzymes. The waste from blanching is hot and contains a considerable amount of dissolved organic matter. Some products which are referred to as formulated products, are further processed by pulping, straining, and/or cooking in vats. Syrups, spices, juices, or brine are added as required. Then the product is generally ready for filling into cans. Only spillages or spoiled solutions cause waste during this step.

Little waste originates from these processes except when equipment is washed. However, when the pulp is wasted as in the production of canned fruit juices, disposal of the pulp and strained solids becomes a solid waste problem.

Insignificant quantities of waste from the product itself arise from can exhausting, sealing, thermoprocessing (sterilizing), and can cooling. However, since cans are usually cooled by water, considerable waste water is generated in this step. This water is relatively clean and is rapidly finding reuse in flume transporting, raw product rinsing, and can cooling.

The Converted Product Handling processes for frozen fruits and vegetables are generally categorized as blanching, washing, cooling, final preparation and inspection, packing, and freezing. Certain products are frozen on belts prior to packing. By far the most significant waste here is the one from the blanching operation.

Generally, the final steps in preparing frozen fruit juices are extraction, screening, deoiling, deaeration, pasteurization and concentration, packing, and freezing. The extraction and screening processes are generally mechanical; e.g., halved oranges, lemons, or grapefruits are pressed and squeezed to remove the juices. Tremendous quantities of solid residues and some liquid wastes result from this operation. Deoiling is accomplished at the same time as deaeration. Since oil is objectionable, deaeration is required to retard decomposition and off-tastes in the juice. If the steam used in the evacuator is condensed to avoid air pollution problems, a liquid waste containing dissolved contaminants results. Generally, none of the other processes in freezing produce major amounts of liquid wastes. Freezing is either slow or rapid. Rapid freezing is usually preferred because it permits less change in the juice product.

Canning of juices requires several of the same processes as freezing; these are extraction by mechanical means, screening and clarification of certain juices, flash pasteurization, mixing of additives, and packing. The quantity and characteristics of the wastes are generally similar to those discussed above for freezing of concentrated fruit juices.

The quantity of wastes from each operation, in terms of both flow and organic load, is variable and primarily a function of the fruit or vegetable being processed. Cooling water appears to be the largest volume contributor, while lye peeling operations are usually very high in volume and BOD. Blanching is also a major source of the wasteload. A consistent source of liquid waste originates in the initial preparation processes, accounting for about one-third of the total wastewater volume and a high percentage of the organic load.

Water consumption and wastewater discharge statistics for the industry reflect some interesting trends. In the five year span from 1959 to 1964, the wastewater discharge decreased an estimated 10 percent while production increased about 11 percent. The reason for this is the greatly increased volume of water recirculated and reused, especially in areas where fresh water is relatively expensive and/or sewer charges have been imposed based on the volume of wastewater discharged. Location of the plant is obviously an important factor; for example, canneries located in California reuse more water than do frozen food plants in the Southeastern United States. It is felt that a great deal more progress can be made in water reuse by promoting its benefits to those plants not now utilizing modern reuse practices and by increased control instrumentation in existing water recirculation systems. An example of the latter problem is the practice of designing plants for maximum raw product capacity without installation of water control instrumentation to reduce water consumption when the plant is operating at less than full capacity.

Based on the industry growth projected by the Business and Defense Services Administration, U.S. Department of Commerce, production will increase at the rate of approximately 3 percent per year during the next 10 years. If such growth occurs, it is highly probable that the wastewater discharged must increase in spite of higher inplant water reuse.

Census Bureau figures, as well as some rather thorough and recent plant surveys, indicate that the expected average volume of waste is about 80 gal per case (equivalent to 24 No. 303 cans). This per case volume includes wastes from processes, cooling and condensing, boiler feed, sanitary services, and all other uses. The average per case wasteload contains about 0.70 lb of BOD, 0.80 lb of SS, and 0.75 lb of TDS for cannery wastes.

Since most processing occurs during a 2 to 4 month summer period, the loads projected onto the Nation's watercourses and municipal waste treatment plants during this peak period are a heavy burden.

The majority of canneries and frozen food processing plants provide minimal treatment prior to discharging into municipal systems, generally virbating screens to remove solids.

Segregation and concentration of food processing wastes, and recycling of process fluids, can reduce total water consumed and improve the solids removal efficiency of pretreatment works. Pre-treatment of wastes containing chemical constituents that are complex, or not readily bio-degradable or are odorous, highly acidic, basic, or otherwise toxic may require special additional costly pre-treatment facilities. Chemical-mechanical facilities involving such processes as precipitation, flotation, scrubbers, neutralization tanks, and other processes can be used to produce an effluent with more acceptable bio-degradable characteristics. The conversion of wastes into a useful resource or alternatively, the modification of the waste producing subprocess to reduce waste, is a generally desirable goal.

Since canning and frozen food processing wastes are largely organic, they are compatible to combined treatment with municipal sewage if the following conditions exist:

- the treatment plant has adequate capacity and is of the proper design to cope with the shock organic loads likely to occur during the relatively short canning season.
- the cannery waste is properly pretreated to prevent slug discharges of hot, alkaline, solids-laden wastes. Usually this can be accomplished by a combination of adequate screening and equalization.

In many municipalities, however, the treatment plant is inadequate to cope with the large seasonal volumes of food processing wastes. The resulting drop in treatment efficiency may cause serious pollution in the receiving waters. This is especially true when the receiving watercourse is flowing at a below average rate; e.g., California rivers during the summer.

There have been changes in the character of modern canned and frozen food processing plants. Whereas twenty years ago the average plant was relatively small, handled one or two products during a few months of the year, and was located outside the large cities; today the average plant is large, more diversified, handles a greater variety of raw materials, functions over a longer period, and is being enveloped by spreading urban development. The modern plant, which requires large quantities of water and discharges large volumes of waste, has had a heavy impact on its urban environment. The cities which have built up to and around the canneries have generally inherited both the need to supply their water and to treat their wastes. When handled properly, these needs have been met and solved. Currently, it is estimated that about 62 percent of the industry's waste is handled by municipal facilities. For 1982, the percentage is projected to be at least 74 percent. At that time the industry may attempt to move closer to the agricultural sources.

There is a definite trend toward increased sewer use charges by municipalities to industries discharging large volume and/or heavily polluted waste waters. The two paramount reasons for this are to stimulate industry to reduce its wasteload discharge and because this industry in common with other wet industries has generally been paying less than its proper share of the cost of collecting and treating its wastes.

An estimated 38 percent of the industry's wastes are disposed of by other means than discharge to municipal sewers. In a recent survey it was found that only one-third of these plants provide waste treatment more extensive than screening. Oxidation ponds and spray irrigation systems were the predominant methods of secondary treatment. The national effort to reduce pollution will create standards for most watercourses in the near future.

It is anticipated that the rigorous enforcement of these standards will force most of those plants not now providing adequate treatment to either connect to a municipal system or construct efficient facilities.

Based on figures released by the Business and Defense Services Administration, U.S. Department of Commerce, the production costs (value added) for canning and freezing of fruits and vegetables average approximately $1.66 per equivalent case. In-plant waste treatment costs average approximately $0.006 per case exclusive of sewer service charges, or 0.4 percent of production costs. Sewer use charges average about $0.008 per case. Thus, the total out-of-pocket cost to a typical plant may average about $0.014 or 0.9 percent of its production cost, exclusive of taxes or assessments.

On a national basis it is estimated that waste treatment costs this industry approximately 2 percent of value added in manufacture. This 2 percent includes in-plant treatment facilities and that portion of industry's taxes attributable to municipal pollution reduction, exclusive of collection system services.

The canning and frozen food industries have many similarities and common problems; however, national statistics reveal several significant differences. The frozen food industry generates approximately twice as much waste water volume per equivalent unit of production as does the canning industry. The amount of pollution load generated per equivalent unit of production however, is approximately the same. The reasons for this difference in volume are that the frozen food processers use larger volumes of cooling water; they are generally located in more abundant water areas; and a much smaller percentage of them discharge to municipal sewers. These factors result in an absence of incentive for the frozen food processers to introduce water conservation techniques into their plants.

Industrial Waste Profile

Canned Fruits and Vegetables - SIC 2033

U. S. Department of the Interior
Federal Water Pollution Control Administration
I. W. P. No. 4 - Canned Fruits and Vegetables

INDUSTRIAL WASTE PROFILE STUDIES
CANNED FRUITS AND VEGETABLES

SIC 2033

INTRODUCTION

In the United States today, more than half of the vegetable crops and nearly half of the fruit crops are being processed, either by freezing or canning. The trend toward processing is still increasing. Food canning plants are located in 49 of the 50 states, Puerto Rico, and the Virgin Islands.

Nearly 2000 canneries, producing every basic type of canned food, process over 1200 different food items, either singly or in combination. In 1966, the retail value of the total canning pack was more than $5 billion.

This profile is limited to a study of the canned fruit and vegetable industry which comprises approximately 60 percent of the total production, with a production value of approximately $3.9 billion. It excludes meat and fish, as well as special items such as soups, baby foods, fruit pies, jams and jellies, and pickled specialties.

Table I (1) (2) depicts the growth of the industry from 1950 to 1966. A case is equivalent to 24 No. 303 cans; i.e., 24 No. 2-½ cans were assumed equivalent to 1.77 cases of No. 303 cans, etc.

Because of the diverse nature of the products and the individuality of each processing plant, it would be impossible to describe each of a multitude of process schemes. However, for the purpose of this report, processes will be generalized for broader evaluation.

TABLE I

CANNED FRUIT AND VEGETABLE PACK

Year	per Million	Canned Fruit	Canned Vegetables	Canned Juice
1950	wt, lb	2880 [3]	5510[3]	2160[3]
	equiv. cases of #303	120	230	90
	retail value $	N.A.	N.A.	N.A.
1954	wt, lb	3620[3]	5900[3]	1920[3]
	equiv. cases of #303	151	246	80
	retail value $	477	740	261
1963	wt, lb	4250[3]	7250 [3]	1710[3]
	equiv. cases of #303	177	302	71
	retail value $	751	1124	472
1965 1966	wt, lb	4520[3]	7620[3]	1982[3]
	equiv. cases of #303	188	318	83
	retail value $	N.A.	N.A.	N.A.

1. 1966 pack statistics except where the latest available information was 1965
2. Exclusive of plums
3. At 24/lb/case of #303 cans

INDUSTRIAL WASTE PROFILE STUDIES
CANNED FRUITS AND VEGETABLES

SIC 2033

I. PROCESSES AND WASTES

A. Fundamental Industry Processes

Due to the diverse nature of the products handled by this industry, a multitude of process schemes could be described. Each cannery is probably unique in its inhouse process. However, for the purposes of this report, processes will be generalized into the following categories:

1. Preliminary Cleaning and Preparation
2. Canning of Fruits and Vegetables
3. Canning of Juices

Meat and fish processing are not included in this study, nor are the canning of specialty items, jams and jellies, or pickles.

Wherever possible, important subprocesses associated with specific fruits and vegetables will be described in detail. An overall schematic diagram of the major processes is to be found in Plate 1 (Process Flow Chart). Four additional simplified typical flow charts for major segments of the food processing industry are shown as Plate Nos. 2 to 5.

1. Preliminary Cleaning and Preparation

Raw products intended for commercial canning must be cleaned. The procedures of cleaning vary with the nature of the food; but all raw foods must be freed of adhering soil, dried juices, insects, and chemical residues. This is accomplished by subjecting the raw foods to water baths and high-pressure water sprays while being conveyed on moving belts or passed through revolving screens. Product wash waters may be fresh or reclaimed from an in-plant operation, but should be of suitable quality. The wasted wash waters contain, in soluble and suspended form, the contaminants removed from the raw product, and juices and fragments of the product being washed.

Important factors affecting the preliminary cleaning process are the method of harvesting, whether field washing is practiced, and the care taken to protect the raw product from damage during transportation from field to cannery. The increasing use of harvesting machines has caused a dirtier raw product containing more debris, leaves, vines, damaged produce, etc. than did the older, hand picking methods. Preliminary washing of the raw product in the field greatly reduces the pollution generated by the cannery, but unfortunately this is not a prevalent practice.

a. Pre-cleaning and inspection: These processes use both "wet" and "dry" methods and also mechanical and hand operations. Agitating by hand, screens, jets of air, and belt and roller systems are examples of "dry" systems; while water (wash) spraying, flotation, soaking, and fluming are "wet" methods.

Tomatoes, for example, are either discharged or dumped directly by hand or mechanical means from the hampers or lug boxes into the soak washer. The purpose of this operation is to loosen much of the adhering soil and other contamination thereby reducing the load on the spray washer. The product moves through the soak tank emerging on a belt after 1 - 3 min (or more), and is washed by overhead spray. This soak/wash operation gives large volumes of waste. Of the 4000 gal/raw ton tomatoes, 880 gal or 22 percent are used for removing the soils and any other foreign matter on the product before further processing. Total suspended solids may range from 180 to 1584 ppm. Grapefruit, on the other hand, is spray washed with 2200 gph compared with a total water use of 22,600 gph; i.e., less than 10 percent of the water is used for washing.

Shelled peas are first cleaned. Three shaker screens are used in the cleaner to remove pieces of pod and vine, fine dirt, and splits. An air blast through which the peas fall takes out light extraneous material. The peas are then put through a flotation washer where the cold water washes away the vine juices and field dirt. Any skins, splits, or other lightweight foreign material is removed by flotation, while any sand or small stones and silt sink and are caught by riffles. The peas then pass through a reel equipped with a fresh water spray where the peas are separated from the wash water. Total suspended solids in the wash water range from 270 to 400 ppm.

In addition to the cold water flotation washer, many canners are now using a froth flotation cleaner. This cleaner operated on a principal of difference in wettability between product and the extraneous material. It has been found to be very efficient in removing nightshade berries, thistle buds, weed seeds, etc. which are less easily wet than peas so that they float out in the froth emulsion while the product such as peas sink.

Sorting operations may select for size, maturity, weight, quality, and/or other characteristics. With some food products (such as peas) there is no sharp line between the sorting and preliminary cleaning. Hand sorting at a "sorting table" remains the method of choice and often combines cleaning and some preliminary preparation.

The husking of corn by machine serves to clean, prepare for processing, sort, and grade in one operation. The "sorting table" may feature several belts or bins or chutes by which the product is handled. Tomatoes use a variation of this method, including the cutting and trimming of spoiled portions.

b. Trimming, Coring, Pitting and Cutting: These operations usually involve both mechanical and hand processing. Trimming is usually a hand operation and frequently takes place at the sorting table or nearby. Product portions are removed for size, weight, quality, or processing needs.

Pears, apples, peaches, olives, cherries and apricots are usually cored or pitted before processing. Coring and cutting of pears and apples is a mechanical process. Peaches and apricots are cut into halves by machinery as the pit is removed. Following the halving and pitting operation, the fruit halves are inspected by hand. Halves from which the pits have not been completely removed are segregated for re-pitting.

c. Peeling: Peeling or skin removal of the product is also an incidental form of cleaning. It can be accomplished by hand, machine, or chemicals.

Mechanical or chemical peeling may be performed for apples, pears, potatoes and other products. Some fruits such as potatoes, beets, turnips, and carrots may be peeled in a cylinder whose walls are abrasive in nature. The drum is rotated and water is introduced.

Formerly, soft fruits and vegetables, such as tomatoes, were first scalded by steam or hot water and then peeled by hand. In most modern plants, tomatoes, peaches, and other fruits are usually peeled by immersion in a hot lye solution, or they may pass under a spray or cascade of the same solution. For example, most clingstone peaches on the Pacific Coast are lye peeled. The peaches are dumped or conveyed on an inclined conveyor belt into a lye peeler where the halves are positioned cup side down and exposed to a heavy flow of 1½ to 5 percent lye solution at a temperature of about 210°F for 45 to 60 seconds. The lye solution is recirculated to conserve caustic, lessening the amount of lye waste. Many canners use wetting agents to facilitate the removal of skins. The wetting agent is added directly to the lye solution. Although the effectiveness of a wetting agent has been somewhat controversial, it has been claimed that its use materially reduces the amount of lye normally used. The first rinse water of the skinned product is usually segregated to produce an effluent with a high wasteload.

A major use of water is the rinse of chemically peeled fruits and vegetables to remove excess peel and caustic residue. Water of suitable quality is used for final rinse. This is reused in the initial wash. The spent peeling solutions are strong wastes, high in organic and inorganic content. Following removal of the peel, the fruit halves are size graded on a shaker grader and then each size is inspected on an inspection belt for off-color and imperfect fruit. These imperfect units, which are unsuitable for halves or slices, are usually diverted to pie stock or fruit cocktail.

d. Product Preparation: This step is the final preparation of the food material prior to transportation to specific secondary operations such as canning, juicing, etc. It consists of several independent operations. Some of the more complex operations require considerable time, labor, and material. Post-sorting, by hand or machine; specialized cutting such as dicing carrots and potatoes; "finger slicing"; size grading; blending; and final inspection are included in this category.

e. Transportation: Washed raw products are transported to and from the various operations by means of belts, flumes, and pumping systems. This is a major use of water. Although the fresh water make-up must be of suitable quality, recirculation is practised to reduce water intake. Chlorination is used to maintain certain recycled waters in sanitary condition. Waste waters from the hydraulic systems contain product materials in soluble and suspended forms.

f. Summary: These preliminary operations, including plant cleanup, can use up to 50 percent or more of the total water used in the canning industry, and they contribute the major portion of solid wastes (screenings) associated with the overall process. Specific values for water use, screenings, and wastes will be detailed in the waste treatment portion of this report.

2. Canning of Fruits and Vegetables

The processes described herein are not necessarily meant to operate in series or in the order indicated. Plate No. 1 Process Flow Chart, shows the diversity of possible schemes.

a. Blanching: Blanching operations are designed to expose the entire product (most green vegetables) to high temperatures for a short period of time. The primary function of this operation is to inactivate or retard bacterial and enzyme action which causes rapid degeneration of quality. Although high sugar content in green peas is a desirable quality, it makes them quite sensitive to sugar-substrate enzymes. Other carbohydrases and proteinases create similar problems.

Secondary desirable effects of blanching include the expelling of air and gases in the product, as well as the reduction of volume of the product. Leaching of sugars, starches, and other soluble organic compounds from the raw fruits or vegetables into the blanch water makes it a very strong liquid waste when discharged.

Depending upon the product and/or availability of equipment, blanching may be accomplished by immersion in hot water (180°-212°F), or exposure to live steam.

b. Pulping and Straining: These operations are usually carried out prior to cooking or, as in the baby food industry, after heating and/or cooking.

c. Cooking: Cooking and other types of heating are applied to several types of foods. Tomato sauce, paste and catsup all require heating (or cooking) with some salt, spice, or acid not included in the usual processing flow.

d. Mixing and Adding: Other constituents are mixed with and added to the main product. These additives are spices, thickening agents, syrups, juices, water, salt, brine, etc. which will enhance the product during heating operations.

e. Inspection and Packing: Final inspection operations involve several sub-component operations depending upon the product. Quantity as well as quality control procedures will cover product examination, including batch quality/quantity control; rejection re-routing; container portion control; total additives prior to filling and sealing; weight control before and after container packing; case packing control; and processing load.

Batch volume for container packing will usually determine final additive characteristics and desired concentration. The addition to the product may be made either in the batch container or in the container itself during packing/filling operations.

Metal cans, glass containers, 55 gal steel drums suitably lined, and plastic-lined fiber-backed drums are used as containers. These are commonly washed prior to use producing a waste water suitable for reuse elsewhere in the plant.

After filling it is desirable to pass the sealed cans through a hot water spray washer following closure to remove any adhering product. It is important that the retorts or continuous cookers are clean to avoid unnecessary cleaning of the cans after processing.

f. Thermo-process: Thermo-processing is the process in which the sealed cans are exposed to high temperature for varying lengths of time depending upon the nature of the product. The purpose of the thermo-process is to render the product commercially sterile by killing all bacterial spores which could spoil the product or cause illness to the consumer. Once the containers are filled, inspected, sealed, thermo-processed, cooled, dried and labeled, they are cased and ready for shipping.

3. Canning of Juices

Following initial preparation, the first step in the canning of juices is extraction. There are several methods, including the following for citrus juices:

Rotary juice extraction - halved oranges are held in depressions in rolls while they are pressed by protuberances within lower rolls.

FMC Inline extraction - oranges are pressed between upper or lower intermeshing multifingered extraction cups.

The Buron Machine - halved fruit is reamed automatically.

Citro-Mat extraction - halved fruit is pressed between rotating rolls, one of which rotates twice as fast as the other.

Extraction of tomato juice may be accomplished by several different types of commercially available extractors. These include either the screw type or paddle type extractors. Screw type extractors press tomatoes between a screw and screen. The perforations in the screen vary but usually are about 0.02 to 0.03 inches in diameter. Some installations are equipped with a shaker screen ahead of the extractor where scald spots along with stems, cores, and other foreign material can be removed.

For all juices, the extraction is followed by a screening operation to remove pulp and seeds.

Citrus juices generally require deoiling which employs heating to about 125°F in a heat exchanger maintained under a vacuum of 26 in. The vapors containing the oil are condensed and run to a decanter where the oil separates and is drawn off the top layer. The lower layer is returned to the deoiler. About 80 percent of the oil is removed in this process.

If deoiling is practiced, deaeration usually occurs at the same time. Otherwise, deaeration is a separate operation. The juice is introduced in a thin film or finely divided particles into a vacuum chamber. Steam used in the evacuator is usually vented to the atmosphere; if condensed, this liquid could contain some pollutants.

If the juice is to be concentrated, it must first be pasteurized. The preferred method of pasteurization is the use of heat exchangers, either tubular or plate type. Juice should be heated to 185°-200°F in a few seconds to inactivate enzymes and destroy spoilage organisms, and then immediately concentrated.

The juice is concentrated in vacuum evaporators. In a vacuum concentration, the water is removed by boiling at moderate temperature under appropriate vacuum. Either a series of single effect evaporators or multiple effect evaporators may be used.

During vacuum concentrating, the volatile constituents are largely removed. For some uses, it is desirable to replace some of these constituents. This has been attempted in the past by either condensing the initial distillate and fractionating to recover some of the volatile constituents which are added back to the concentrate, or by adding terpeneless orange oil.

Tomato juice is sometimes homogenized to produce a thicker-bodied product and to prevent settling of the solids. The general practice is to eliminate the homogenation particularly when "hot break" juice is being packed. When homogenizers are employed they are operated between 1000 and 1500 lb per sq in of pressure at a juice temperature of about 150°F.

B. Significant Pollutants

Waste materials that originate from fruit and vegetable canning operations are of two classes: solid materials, such as trimmings, pits, peels, leaves, stems, and defective whole pieces that are discarded within the plant; and waste materials such as sugars, starches, and other carbohydrate-like compounds exuded or leached from the raw or cooked product and carried in solution in the wash or flume waters used in preparing and processing the food.

The total volume of waste materials, and the nature and concentration of suspended and soluble organic materials in the waste streams from food canning operations, vary widely with the type of raw product being processed and with the methods employed in individual plants. Aside from factors beyond the direct control of the canner, such as the quality and maturity of the fruit or vegetable, variations in the volume and pollution-potential of the waste streams are caused by differences in rate of raw product in-put, the extent of hydraulic transport of raw product, the degree of recirculation of process waters, the extent of in-plant transport of solid wastes, the general orderliness and good housekeeping within the plant, and the effectiveness of the final screening of the composite waste stream.

When untreated fruit and vegetable processing wastes are discharged to a stream or other body of water, the ability of the stream to assimilate the waste without showing evidence of pollution depends largely on the relationship between the volume and strength of the waste discharged at a given time and the volume and flow rate of the receiving water. Carbohydrate materials in the food canning waste can initiate rapid and abundant microbial growth in the receiving water. The most common and expected pollution effect is depletion of the oxygen supply in the stream to the extent that fish life is killed. If oxygen is used without replenishment, anaerobic decomposition of the waste begins with production of odors, discoloration of the stream, and other nuisance conditions.

Thermal pollution is a possibility if waters from a container-cooling operation or from a product evaporation-concentration system enter streams before the heat has been dissipated.

Air pollution due to direct emission of volatiles or air-borne particles has not been shown to require immediate attention. Furthermore, there is no apparent possibility that unique air pollution hazards will result from chemical or physical conversion of water-borne waste materials, in terms of today's emission standards.

Significant pollutants in this industry arise from the following operations:

1. Hot Lye Peeling
2. Sorting, Slicing, Cutting, Blending, Etc.
3. Processing
4. Washing (several washes are used in most plants)
5. Exhausting of Cans
6. Cooling of Cans
7. Plant Cleanup
8. Box Washing

The combined wastes have the objectionable characteristics of high BOD, TDS, and suspended solids. The peeling, coring and blanching operations supply particularly concentrated wastes.

C. Process Water Reuse - 1964

The state of the art in food processing plants appears to involve continuous recirculation of waters with limited make-up and blow-down for a particular subprocess. For example, wash waters for most produce can be continuously recycled within an optimum system. Final rinsing removes the residual dirty water and this serves as make-up for the initial scrub washing subprocess. Similarly, flume water used for the carriage of fruits and vegetables is continuously recycled and builds up a high organic content. Low pH and appropriate bactericides can be used as a means to control bacterial growth. The rinse spray is used again to make up the flume water. Blow-down of the subprocess water system and wash-up normally follow each shift.

Cooling tower recirculation is a common method of conserving water. The cooling tower blow-down can be used for supply water with the various subprocesses of the packing plant. Evaporator waters may be reused for processes, especially washing, initial washing, etc.

The improved food handling subsystems also promote general plant sanitation and conserve water by requiring less washdown water.

For example, culls are normally segregated at sorting belts, and partially damaged fruit of good quality is transported to subprocess where pulping for juice occurs.

Better food process handling throughout the nation is resulting in lower labor requirements, less error, less waste and significantly increased production rates per gal of process water. For example, a modern peach cutting machine is similar in design to earlier equipment, but operates at higher rates, with less damage to the fruit, and better cutting efficiency, thereby reducing the solid wasteload. In summary, it can be said that the trend of modern food processing plants is toward increased automation resulting in improved efficiency, increased production per unit of plant area, and less dependency on the seasonal labor force.

The increasing costs of water, and sewer service charges based on flow volume and pollution content, are also acting as incentives to optimize the conservation and reuse of water within the food processing industry. Recent surveys of eleven California canneries indicate that water conservation and reuse can reduce water use per unit of product up to 40 percent.

The following is a tabulation (3) of the industry's 1963 water intake, water use and reuse, and waste discharge for canned fruit and vegetable processing plants throughout the nation. It should be noted this tabulation does not include plants using less than 20 MG/yr.

Item	Water Quantity in billion gal/yr	Percent of Intake Quantity
Water Intake	35	100
Process	20	57
Cooling, Condensing	10	29
Boiler Feed Sanitary service & Other	5	14
Recirculated Water	16	46
Consumption	2	6
Discharge	33	94

Only 239 of the 1600 canneries reported in the 1963 Census of Manufacturers. Based on other statistics from the census, it was calculated that the industry's total water intake and waste discharge were as follows:

	Quantity in billion gal/yr	
	Intake	Discharge
Canned Fruits and Vegetables	40	38

It should be noted that these quantities include the wastes generated by secondary processing in plants such as those producing jams, jellies, and preserves packaged under the classification of Canned Fruits and Vegetables SIC 2033. However, discussion within this report excludes these secondary-type processors. An independent survey of several representative plants shows the following relatively high reuse of water.

	Intake	Recirculated	Gross Applied	Liquid Waste
11 California canneries	4220 (5)	3400 (100)	8300 (6)	3600 (3)
5 other canneries	4500 (8)	600 (3)	5100 (6)	3600 (6)
Tomato Cannery	4200	3400	7600	3600
Peach Cannery	5400	4000	9400	4500

Figures in parentheses are the ratios of the maximum to the minimum estimates of the volumes.

The industry as a whole estimates that in 1966 approximately 50 percent of process water was reused at least once. In many instances waters from certain processes are reused many times.

It is felt that a great deal more progress can be made in water reuse by promoting its benefits to those plants not now utilizing modern reuse practices and by increased control instrumentation in existing water recirculation systems. An example of the latter problem is the practice of designing plants for maximum raw product capacity without installation of water control instrumentation to reduce water consumption when the plant is operating below full capacity.The volume of water used per unit of production increases significantly when a plant is operating below its maximum capacity.

D. Subprocess Trends

Table I-1 describes the predominating subprocess mixes for the canned and frozen fruit and vegetable industry. The industry is divided into two segments: Canned Fruit Juices, and Canned Fruits and Vegetables. Figures shown are percentages of that section of the industry noted using each subprocess. The total percentage may be less than, equal to, or more than 100 percent because many plants do not use all of the subprocesses shown while others use several methods to accomplish one subprocess. Some of the subprocesses are characteristic of only one segment of the industry. For example, clarification is a subprocess used in the production of clear fruit juices. Therefore, the figures shown reflect the percentage of that portion of the industry involved in fruit juice production. Totals for any given subprocess may increase or decrease due to the change in size of the segment of the industry using the given subprocess relative to the rest of the industry.

Insight into these processes was achieved by thoroughly reviewing available literature, interviewing key personnel within the industry, observing operations in several representative plants, and analyzing production quantities given in the 1967

Almanac of the Canning, Freezing, and Preserving Industries.(1)

The tables consist of three sections as follows:

A) Initial Preparation
B) Canned Fruit Juices
C) Canned Fruits and Vegetables

In general, the subprocesses listed under Initial Preparation are used by both segments of the industry. Those listed under the other two sections characterize only that segment.

TABLE I-1 SUBPROCESS TRENDS

Fundamental Process and Subprocesses	Percentage of Total Plants				
	1950	1963	1967	1972	1982
SECTION A - INITIAL PREPARATION					
Field Clearing	2	5	8	15	30
Pre-Cleaning					
1. Spray Wash, Rinse	50	60	60	60	60
2. Detergent Wash & Rinse	5	5	5	10	10
3. Water Soak Only	15	10	5	5	-
4. Water & Rinse Bath	20	15	10	5	5
5. Brine	5	5	5	5	5
6. Flume	5	5	10	10	10
7. Dry Cleaning	-	-	5	5	10
Sorting					
1. Mechanical					
a. Screening (size grad-	10	20	20	25	35
b. Flotation ing)	10	15	20	25	25
2. Hand	95	85	85	75	70
Trimming					
1. Hand	40	35	35	30	20
2. Silking & Husking	5	5	5	5	5
3. Mechanical	5	10	10	15	25
Coring & Pitting					
1. Hand	15	10	10	8	5
2. Mechanical	20	25	25	27	30
3. Kernel Cutter	5	5	5	5	5
Cutting					
1. Slicing	35	35	35	35	35
2. Dicing	5	10	10	15	15
3. Halving	15	15	15	15	15
4. Snipping	15	10	10	5	5
Peeling					
1. Steam Scalding	20	10	8	5	2
2. Hot Lye	10	30	35	40	50
3. Abrasion	10	5	5	5	4
4. Mechanical Knives	20	15	12	10	4

Fundamental Process and Subprocesses	Percentage of Total Plants				
	1950	1963	1967	1972	1982
SECTION A (cont'd)					
Grading & Inspection					
1. Eye	100	100	98	95	85
2. Photo-Med. Color	-	-	2	5	15
Transport					
1. Primary Flume (Water)	45	60	65	70	70
2. Conveyor Belt	75	80	85	90	95
3. Cart/Truck/Hand	10	8	6	3	2
Product Waste Disposal					
1. Floor Disposal	5	3	2	1	-
2. In-process Bin Collection	30	20	13	9	5
3. Conveyors	20	10	10	20	30
4. Floor Gutters & Flumes	100	100	100	100	100
Plant Clean-up	100	100	100	100	100
SECTION B - CANNED FRUIT JUICES					
Extraction					
1. Crush/Press	10	10	10	10	10
2. Reaming	25	25	25	25	25
3. Pulping	65	65	65	65	65
Screening					
1. Mesh Screen	40	40	40	40	40
2. Centrifuge	30	30	30	30	30
De-Oil					
1. Heating in Vac.	15	25	30	32	35
De-Aerate	1	1	1	1	1
Clarification					
1. Gelatin & Tannin	5	3	2	1	1
2. Pectic Enzyme	8	13	15	17	17
3. Flash Heating	5	2	1	-	-
4. Freezing & Thawing	2	2	2	2	2

Fundamental Process and Subprocesses	Percentage of Total Plants				
	1950	1963	1967	1972	1982
SECTION B (cont'd)					
Pasteurization					
1. Pasteurization Only	90	80	80	75	70
2. Pasteurization & Concentration	10	20	20	25	30
Solid Waste Product Handling					
1. Floor Disposal	5	3	2	-	-
2. In-process Bin Collection	25	15	10	10	5
3. Conveyors	20	15	18	20	30
4. Floor Gutters & Flumes	45	65	70	70	65
Plant Clean-Up	100	100	100	100	100
SECTION C - CANNED FRUITS AND VEGETABLES					
Blanching					
1. Hot Water	35	35	35	38	38
2. Steam	5	5	5	4	3
Mixing and Adding					
1. Syrup, Spice and/or Juice Addition	40	40	40	40	40
2. Brine	60	60	60	60	60
3. Pulping & Straining	5	5	5	4	4
Vat Cooking	25	30	32	35	40
Filling					
1. Hand	70	50	40	25	10
2. Mechanical	30	50	60	75	90
Can Exhaust					
1. Mechanical Vacuum	25	25	25	20	15
2. Exhaust Boxes	80	60	50	40	30
3. Steam Flow	20	40	50	55	65
4. Hot Fill	40	40	40	35	30
Seal & Thermo Process	100	100	100	100	100

Fundamental Process and Subprocesses	Percentage of Total Plants				
	1950	1963	1967	1962	1982
SECTION C (cont'd)					
Can Cooling					
1. Water	95	100	100	100	100
2. Air	10	10	1	1	0
Solid Waste Product Handling					
1. Bin Collection	10	8	6	5	2
2. Floor Gutters or Flumes	55	72	82	75	65
3. Conveyors	25	15	10	20	33
Plant Clean-up	100	100	100	100	100

E. Waste Control Problems

The canning industry is unusual in that the product handled is in itself extremely bio-degradable resulting in a waste which is among the strongest in terms of BOD of all industries. It has approximately ten times the strength of domestic sewage. Due to the necessity of rejecting spoiled and overripe portions of food, the canning industry produces a large amount of solid wastes.

The rinse following chemical peeling (where used) can contribute as much as 40 percent of the plant BOD. The waste from this process is highly alkaline and may require neutralization prior to biological treatment. In addition, a portion of the product is dissolved by the lye and enters the waste stream.

Raw product washing is another major source of pollution. In this process, all of the dirt, vegetation, and pesticide residues are removed, often with the aid of detergents which create an additional wasteload. On the other hand, the spray rinse after washing requires a large amount of water (15 percent of total plant water), but the pollutant content is low.

Plant clean-up is a secondary source of pollution. Most solid matter reaching the floor accidentally, and spilled juices and solid matter remaining on equipment are flushed into floor drains.

F. Subprocesses Technologies

There has been no basic change in the series of subprocesses used in the production of canned fruits and vegetables since 1950. Most of the changes have been refinements and optimization of older practices. These technological improvements resulting in higher production rates and better product quality have not reduced wasteloads to any great extent. The trend toward increased use of flumes for product transport has reduced the quantity of rejected food waste. Furthermore, utilization of nozzles employing high pressure and low volume will reduce rinse water requirements. Disposal of solids reaching the floor by sweeping and collecting, followed by nominal wet washing, can reduce wastewater volumes, BOD, and suspended solids. Increased use of conveyors for dry disposal of rejects and wastes may be employed more in the future to conserve water and reduce the liquid wasteload.

An optimum plant design with complete water conservation and a good housekeeping program can reduce wastewater volume by more than 50 percent.

The waste production of older, prevalent, and new technologies cannot be specifically described. However, the trend is toward greater recirculation and reduced water intake, resulting in a decreased volume of liquid wastes containing a higher concentration of pullutants.

The industry reports increased use of field washing and sorting stations, thereby eliminating these steps in the cannery. This is highly beneficial in reducing pollution generated by the canneries and should be strongly encouraged.

Chemical peeling is used increasingly. Unfortunately, this process generally produces greater dissolved organic and inorganic pollution than do the alternate mechanical processes. Mechanical abrasion or knife peeling produces largely solid wastes which are not discharged to the sewer.

A very complete discussion of plant sizes as related to region of the country, raw product volume, and number of products handled is contained in the U.S. Department of Agriculture, Economic Research Service canner survey, 1965. It reveals that in 1963 the average output per plant amounted to 371,648 case equivalents of size 303 cans. The regional average varied from 152,000 case equivalents in the Eastern United States to 700,000 case equivalents in the Western United States.

Based on an arbitrary plant size classification of:

Small plant - less than 210,000 cases / year
Medium plant - 210,000 to 800,000 cases / year
Large plant - over 800,000 cases / year

The percentage of plants in each classification is estimated as follows:

Small plant - 35 percent
Medium plant - 33 percent
Large plant - 32 percent

There is a definite indication that many of the small firms are hard pressed to compete and that the percentage of small firms will decrease in the future as a result. Many small firms are discouraged from making investments in new plant equipment and thus do not participate in the cost savings of modern production technology.

As previously stated the principal difference between old, prevalent, and newer technology in this industry is not in the operational sequence, but rather in the speed and efficiency of the machinery performing the operations. New production machinery is generally very expensive and can only be justified by adequate production volume; it follows, therefore, that in general the larger plants fall into the newer and prevalent technology categories and the small plants tend toward the older technology classification.

It is estimated that the percentage of plants falling into each classification is as follows:

	Percent In Each Technology Classification		
Plant Size	**Older**	**Prevalent**	**Newer**
Small	40	50	10
Medium	20	50	30
Large	10	40	50

II. GROSS WASTE QUANTITIES

A. Daily Waste Quantities

Data describing individual waste streams from each process in a fictitious average food processing plant are reported in Table II-1. The wasteloads noted are those prior to any screening or other treatment. The loading per case is based on equivalent cases of 24 - No. 303 cans for vegetables and 24 - No. 2 1/2 cans for fruit. Results of a recent survey (4) of a tomato cannery in California are included as Table II-2 to provide a further example of representative plant conditions.

The total waste quantities and wastewater volumes, both ranges and averages, are included in Table II-1. However, although the total quantity of waste generated in a canning operation is an important parameter for determining gross pollutional discharge, treatment methods and effects require an intimate knowledge of wastes associated with each process within the cannery.

The distribution of water used in the various processes in a typical cannery is summarized below. This tabulation was based on the operation of many different plants. Individual plants will vary widely, of course.

Operation	Gross Water Application %	
	Range	Average
Raw Product Preparation (including peeling)	25-55	34
Syrup and Brine	2-10	6
Steam and Sterilization	10-20	14
Cooling	6-60	35
Clean-up	5-25	8
Other	1- 6	3

Additional study is certainly required to determine the effect of changes in plant operations upon the wasteload generated. This would involve the thorough evaluation of the alternates available and the economic factors involved.

TABLE II-1 DAILY WASTE QUANTITIES

Subprocesses of Prevalent Technology	Wasteload, Lb/Day for Average Size Plant Producing 10,000 Cases/Day			Wastewater Volume (mgd)
	BOD	SS	TDS	
Washing	500 - 3,000	500 - 4,000	300 - 1,500	.080 - .250
Belt Conveyor	30 - 100	100 - 200	30 - 100	.010 - .050
Sorting, Pitting, Slicing, Etc.	50 - 600	150 - 700	100 - 500	.010 - .075
Blanching and/or Peeling	1,500 - 4,000	1,000 - 4,000	2,000 - 4,000	.060 - .250
Exhausting of Cans	0 - 150	0 - 150	0 - 200	0 - .025
Processing	50 - 600	50 - 450	40 - 1,200	.010 - .050
Cooling of Cans	50 - 600	50 - 300	300 - 1,000	.060 - .300
Plant Cleanup	320 - 1,200	300 - 1,500	230 - 1,000	.060 - .200
Box Washing	100 - 250	150 - 400	200 - 500	.020 - .050
TOTAL	2,600 - 10,500	2,300 - 11,700	3,200 - 10,000	.310 - 1.250
AVERAGE	7,000	8,000	7,500	0.750

1. Normal canning season and period of major waste discharge averages 3 months per year.

2. Fluming volumes and wasteloads are included with their associated subprocesses.

3. Average waste at about 0.5 mgd.

TABLE II-1 DAILY WASTE QUANTITIES

Subprocesses of Newer Technology	Wasteload, Lb/Day for Average Size Plant Producing 10,000 Cases/Day			Wastewater Volume (mgd)
	BOD	SS	TDS	
High Pressure - Low Volume Wash sprays following Mechanical Harvesting	500 - 3,000	200 - 5,000	300 - 1,500	.060 - .200
Belt Conveyor	20 - 100	20 - 200	30 - 60	.010 - .030
Mechanical Sorting, Trimming, Pitting, etc.	50 - 600	100 - 700	80 - 400	0 - .060
Blanching and/or Peeling	1,500 - 4,000	900 - 4,000	2,000 - 4,000	.060 - .250
Exhausting of Cans	0 - 100	0 - 100	0 - 140	0 - .020
Processing	50 - 500	40 - 500	40 - 200	.010 - .050
Cooling of Cans	50 - 600	40 - 800	200 - 1,300	.040 - .240
Plant Cleanup	180 - 1,000	200 - 1,200	150 - 800	.050 - .100
Box Washing	50 - 200	100 - 400	200 - 500	.020 - .050
TOTAL	2,400 - 10,100	2,100 - 12,900	3,000 - 8,900	.250 - 1.000
AVERAGE	6,500	7,500	6,700	.650

TABLE II - 2

DISTRIBUTION OF LOAD FROM TOMATO PROCESSING WASTE STREAM

	Proportion of Total Plant Load(%)		
Product Cleaning	**Flow**	**BOD**	**SS**
Wastewater from tomato lug box dump tank and flume.	9.6	6.0	7.4
Wastewater from first spray rinse on draper belt after tomato dump tank.	7.0	3.5	4.4
Wastewater from second and third spray rinses following tomato dump tank	11.8	1.8	2.8
Subtotal	28.4	11.3	14.6
Lye Peeling and Rinse			
Wastewater from flume transporting tomatoes from sorting area to lye peelers (lye drippings from lye peeler elevator boot were included in this waste).	0.9	-	2.5
Wastewater from overflow flume following lye peeling (1st rinse).	4.3	12.2	18.2
Wastewater from elevator boot under the tomato skin removal sleeves and sprays (2nd rinse).	7.8	26.7	19.4
Wastewater from rinse and skin removal flumes following skin removal sleeves (3rd rinse).	12.2	5.2	5.5
Wastewater from flumes transporting tomatoes from peeling area to canning belts	17.2	10.4	4.9
Subtotal	42.4	54.5	50.5
Sorting and Can Packing			
Wastewater from sorting and belts - west half	1.9	0.6	0.5
Wastewater from sorting and belts - east half	2.2	0.3	0.5
Subtotal	4.1	0.9	1.0

Can Cooling		Proportion of Total Plant Loan(%) Flow	BOD	SS
Wastewater from cooling hot (processed) cans		15.5	3.0	3.4
	Subtotal	15.5	3.0	3.4
	TOTAL	90.4	69.7	69.5

B. Wasteload Production Rates

Table II-3 illustrates the varying wasteloads generated by different fruits and vegetables. The variety of processes employed by different canneries results in the ranges of wasteloads.

A summary of average waste loads produced per case of food processed follows:

	BOD (lb)	SS (lb)	TDS (lb)	Volume (gal)
Prevalent	0.7	0.8	0.75	75
Newer	0.65	0.75	0.67	65

C. Total Wasteload

The following estimates for total wasteload generated in 1963 were derived by using the average wasteload and volume figures given in Section II A under "Prevalent Technology" and assuming the subprocess mix as given in Section I D.

BOD (million lb)	SS (million lb)	TDS (million lb)	Volume (billion gal)
370	425	395	36

D. Gross Wasteload Projection

The following wasteload projections are based on the values provided by the FWPCA and on the trend for most prevalent subprocesses. It is assumed that water requirements and waste production per unit production will be reduced as greater recirculation and improved methods and equipment are adopted in the future.

Year	1968	1969	1970	1971	1972	1977
BOD, million lb	435	445	455	460	465	490
SS, million lb	500	510	520	525	535	565
TDS, million lb	465	475	485	490	495	525
Vol., billion gal	39	40	40.5	41	41.5	44

E. Seasonal Variation

Canning plants are characterized by seasonal variations with many operating only 2 or 3 months each year.(5) Most plants process more than one type of product and may be confronted with overlapping seasons during which production schedules are increased. Certain products can be prepared immediately after picking and stored for further processing throughout the year, thus reducing peaks of both production and waste discharges.

TABLE II-3

TYPICAL CANNING WASTES

Product	Waste Volume (gal/case)	5-Day BOD[1] (mg/l)	5-Day BOD[1] (lb/case)	Suspended Solids[1] (mg/l)	Suspended Solids[1] (lb/case)
Apples	29- 46	1,680-5,530	0.64-1.31	300- 600	0.10-0.20
Apricots	65- 91	200-1,020	0.15-0.56	200- 400	0.14-0.25
Cherries	14- 46	700-2,100	0.16-0.50	200- 600	0.05-0.14
Cranberries	11- 23	500-2,250	0.10-0.21	100- 250	0.02-0.05
Pineapples (7)	74	26	0.002	-	-
Peaches	51- 69	1,200-2,800	0.69-1.20	450- 750	0.24-0.34
Asparagus	80	16- 100	0.01-0.07	30- 180	0.02-0.12
Beans, Baked	40	925-1,440	0.31-0.48	225	0.07
Beans, Green/Wax	30- 51	160- 600	0.15-0.67	60- 150	0.02-0.04
Beans, Kidney	20- 23	1,030-2,500	0.19-0.45	140	0.02
Beans, Lima, Dried	20- 33	1,740-2,880	0.30-0.60	160- 600	0.05-0.10
Beans, Lima, Fresh	57-294	190- 450	0.21-0.47	420	0.20-1.02
Beets	31- 80	1,580-7,600	1.00-2.00	740-2,220	0.50-1.00

TABLE II-3 (cont'd)

Product	Waste Volume (gal/case)	5-Day BOD[1] (mg/l)	5-Day BOD[1] (lb case)	Suspended Solids[1] (mg/l)	Suspended Solids[1] (lb/case)
Carrots	36	520- 3,030	0.11-0.67	1,830	0.40
Corn, Cream Style	28- 33	620- 2,900	0.17-0.66	300- 675	0.07-0.17
Corn Whole Kernel	29- 80	1,120- 6,300	0.74-1.50	300-4,000	0.20-0.95
Mushrooms[2]		76- 850	4.77-53.38	50- 240	3.14-15.07
Peas	16- 86	380- 4,700	0.27-0.63	270- 400	0.06-0.20
Potatoes, Sweet	90	1,500- 5,600	1.10-4.40	400-2,500	0.31-1.95
Potatoes, White	-	200- 2,900	-	990-1,180	-
Pumpkin	23-57	1,500- 6,880	0.72-1.31	785-1,960	0.38
Sauerkraut	3-20	1,400- 6,300	0.10-0.30	60- 630	0.01-0.10
Spinach	180	280- 730	0.42-1.11	90- 580	0.14-0.88
Squash	23	4,000-11,000	0.76-2.09	3,000	0.57
Tomatoes	3-114	180- 4,000	0.11-0.17	140-2,000	0.06-0.13

1. It should be noted that the normal engineering technology describes the wasteload in mg/l or ppm. In most parts of this report the wasteloads were described on the basis normally used by industry--lb/equivalent case. To convert mg/l to lb/case, multiply the mg/l loading by 8.33 x 10^{-6} lb/gal and multiply by the waste volume discharged in gal/case.

2. Per Ton

Tables II-4 (1) and II-5 (1) are summaries of the seasons for canning and freezing the most common fruits and vegetables. Major changes in these variations are not expected because these seasons depend on weather conditions. However, a trend toward preparatory processing and storage, with final processing being spread over the remainder of the year, could develop for certain products.

TABLE II - 4

CANNING SEASON - FRUITS

	FRUIT	NUMBER OF STATES PROCESSING	OPENING AND CLOSING MONTHS	LENGTH OF RANGE	SEASON, MO. AVERAGE
	Apples	16	Aug. - Jan.	2-4	4
	Apricots	6	June - Sept.	0.5-2	1
BERRIES	Black	10	June - Oct.	0.5-2	1
	Blue	5	June - Oct.	1-2	1
	Cran	3	Sept. - Jan.	1	1
	Goose	4	May - Aug.	1-2	1
	Logan	2	June - Aug.	1.5	1.5
	Rasp	6	July - Aug.	0.5-1	1
	Straw	8	April - Oct.	1-6	1
	Cherries	11	May - Aug.	1-2	1
	Figs	4	May - Nov.	1.5-3	2
	Grapes	6	Aug. - Nov.	1-2	1.5
	Grapefruit	4	Nov. - May	5-8	6
	Lemons	1	All Year	12	12
	Olives	1	Oct. - Feb.	4	4
	Oranges	2	July - June	4.5-6	5
	Peaches	18	June - Sept.	0.5-2	1
	Pears	10	July - Jan.	1-4	2
	Pineapple	2	Jan. - Nov.	1-4	2
	Plums	5	July - Nov.	1-2	1.5
	Prunes	6	All Year	1-12	1

TABLE II - 5

CANNING SEASON - VEGETABLES

VEGETABLE	NUMBER OF STATES PROCESSING	OPENING AND CLOSING MONTHS	LENGTH OF SEASON, MO.	
			RANGE	AVERAGE
Pickles	7	All Year	12	12
Pimentos	6	Aug. - Dec.	1.5-3	2
Pumpkin	16	Sept.- Nov.	1-2	1.5
Rhubarb	5	May - June	0.5-1	1
Spinach	15	Feb. - Dec.	0.5-4	2.5
Sprouts	0			
Squash	10	Oct. - Nov.	0.5-2	1.5
Succotash	6	Aug. - Oct.	0.5-2	1.5
Sweet Potato	12	July - Feb.	2-7	4
Tomatoes	30	Mar. - Dec.	1.5-6	2
Artichokes	1	Feb. - May	3	3
Asparagus	13	Apr. - Oct.	2-3	2
Lima Beans	13	July - Oct.	1-4	2
Snap Beans	31	May - Oct.	1-4	2
Beets	14	June - May	1-6	3
Corn	20	June - Oct.	1-2	1
Carrots	7	Sept.- May	1-6	2
Kraut	12	All Year	12	12
Okra	8	May - Sept.	2-4	3
Peas	20	Apr. - Oct.	1-2	2

III. WASTE REDUCTION PRACTICES

A. Processing Practices

Table III-1 is a list of alternative subprocesses for each fundamental process where waste reductions can be, or have been, achieved through process changes. The waste reduction efficiencies are based on the subprocesses typical of older technology levels. Only the subprocesses contributing the major wasteloads and those providing significant reductions have been listed.

B. Treatment Practices

The treatment of cannery wastes can be divided into two categories: (1) partial or complete treatment by the industry, and (2) municipal treatment. Most canneries discharge into municipal sewers with minimal preliminary treatment - usually only vibrating screens to remove part of the suspended solids. In a recent survey of 113 canneries, 68 percent screened their wastes which were subsequently discharged to the municipal sewer system, while only 13 percent used their own treatment plants; 2 percent had no treatment; and 17 percent either were no longer in operation or supplied no information. Of the 14 plants providing their own treatment, 3 used screens only; 6 used oxidation ponds after screening; 2, spray irrigation after screening; 1, screening plus neutralization; 1, screening, sedimentation, and ridge and furrow irrigation; and 1, screening, sedimentation, neutralization, and nutrient addition followed by aeration.

Segregation of high strength low volume waste streams is one economically feasible approach to in-plant waste treatment. A strong waste representing only 2-5 percent of the total plant flow but containing 70-75 percent of the total organic load is normally much more economical to treat efficiently than a large volume of waste relatively low in BOD, SS, and TDS.

Numerous treatment schemes have been employed by the industry and by municipalities; however, due to the seasonal and complex nature of the cannery operation, reliable performance and cost data are difficult to obtain. This study will consider industrial treatment of both liquid and solid waste. Reference is made to Plate 6 for an overall treatment and disposal schematic (Waste Treatment Flow Chart). Table III-2 lists approximate removal efficiencies.

1. Removal Efficiencies

Each unit operation and process is evaluated separately. Wherever possible, applicable performance data is reported. Overall treatment efficiencies for combination operations and processes can be determined from individual performance data.

TABLE III-1 PROCESS POLLUTION REDUCTION

Fundamental Processes and Subprocesses	Waste Reduction Efficiency (%)	
	Wasteload	Water Volume
Pre-Cleaning		
In-Plant Wash/Rinse	0	0
Field Pre-Cleaning	50 - 80	50 - 60
Spray Washing	0	25
Recirculation	0	50 - 80
Sorting		
Dry	0 - 20	40 - 60
Wet (Flotation)	0	0
Peeling		
Mechanical	0	0
Hot Lye	10 - 40	10 - 30
Steam Scalding	5 - 10	5 - 10
Transport		
Water (Flume)	0	0
Mechanical	15 - 20	90 - 100
Water w/Recirculation	0	50
Blanching		
Steam	0 - 10	30 - 60
Hot Water	0	0
Can Cooling		
Water	0	0
Water w/Recirculation	0	75
Product Waste Disposal		
Floor Disposal	0	0
Bin Collection	50 - 90	50 - 90
Conveyors	50 - 90	50 - 90
Flumes & Floor Gutters	0	0

TABLE III-2

TREATMENT REMOVAL EFFICIENCY

Method	POLLUTION REDUCTION (%) Flow to Surface Water	BOD to Surface Water	SS to Surface Water
Screening 20-40 Mesh	0	0-10	56-80
Wet Oxidation	-	-	-
Sedimentation	0	10-30	50-80
Flotation	0	10-30	50-80
Chemical Precipitation	0	39-89	70-90
Chemical Oxidation	-	-	-
Activated Sludge	0	59-97	90-95
Trickling Filtration	0	36-99	85-90
Anaerobic Fermentation	0	40-95	-
Lagooning	0-50	83-99	50-99
Spray Irrigation	50-100	100	100
Sand Filtration	50-100	15-85	100

a. Liquid Wastes: Table III-2 summarizes the efficiencies of various treatment methods employed in 1963.

1) Screening: Screening is almost universally the first treatment step employed in the canning industry. The operation is usually carried out with stationary, rotary, or vibrating screens having a 20-40 mesh size.

Gyrating, circular screens have been used to a limited extent; meaningful statistical data is not yet available, but the 3-way vibration allows the use of finer screen cloths and removal of more suspended matter.

Following is a summary of the performance of several screens used in canneries.

Screen Type	Mesh	Loading	Waste	Removal Efficiency	Ref.
Rotary	6-10	3.5 gal/ sq ft/min	-	-	(8)
Vibrating	20-40	32-70 gal/ sq ft/min	-	-	(8)
Vibrating	50	8000-12,000 gal/hr	pea	400-600 lb	(9)
Rotary	28	-	red beet, tomato	56% SS 79.7% SS	(10)
Revolving	40	200 gal/ sq ft/hr	pea	0.8 cu ft/ 1000 gal	(11)
Vibrating	40	975 gal/ sq ft/hr	-	135 lb/ sq ft/hr	(12)

In a few instances other means of mechanical solids separation have been tried, such as microstrainers and centrifuges. Theoretically, these devices would achieve higher removal efficiencies, and their wider use appears worthy of research investigation.

2) Grease Removal: Negligible quantities of grease are normally present in cannery operations.

3) Sedimentation/Flotation: These two operations are employed (usually separately) to remove solids which are either readily settleable or floatable. Little definitive information is available on the efficiency of either process although peach and tomato wastes have been treated by flotation (6) with loadings of 7000 gal/sq ft subjected to 8-10 in of mercury vacuum, yielding suspended solids removals of 50-80 percent.

4) Chemical Coagulation and Precipitation: Chemical agents such as lime and iron salts have been used to precipitate cannery wastes but are not widely utilized due to variation in efficiency and high chemical costs. The following tabulation shows results with several wastes and indicates suspended solids removals up to 90 percent and BOD removals up to 75 percent. Other studies(13) indicate BOD removal as high as 89 percent.

CHEMICAL TREATMENT OF CANNERY WASTES

	Chemicals			Reduction Efficiency (%)	
Waste	Lime	Alum	$FeSO_4$	SS	BOD
Tomato	8.3	...	...	86.5	39.0
	4.0	1.0	...	...	50.0
Red Beets	9.0		...	90.0	43.0
	10.0	...	4.0	...	59.0
	10.0	...	...	...	48.0
Corn	9.10	...	9-12	...	60.0
	6.0	...	3.25	...	50-75
Carrots	5.0	...	1.0	...	75.0
	8.0	...	...	...	75.0
Peas	7.5	...	3.25	...	50-75
Wax Beans	6.0		2.5	...	50-75

5) Chemical Oxidation: Relatively little has been reported in the way of successful chemical oxidation. Generally, the amount of chlorine required to oxidize the waste is excessive, and BOD reduction data is presently unavailable.

6) Biological Treatment: Most cannery wastes contain a fairly high percentage of dissolved and colloidal organic solids. This should lead to successful application of biological processes to cannery waste treatment; however, due to the cost factor, the highly seasonal nature of the canning operation, and the lack of many specific nutrients in the wastes, successful high rate biological stabilization has been rare. However, as shown in Table III-3, lagooning has been successfuly employed.

Experimental trickling filters have been found to have removal efficiencies of over 90 percent(9) for cannery wastes. It was necessary, however, to reduce the loadings to achieve this high efficiency. Normal loadings for standard rate trickling filters are 0.22 to 0.38 lb BOD/cu yd/day, whereas the above experiments used 0.04 lb BOD/cu yd/day. Other experiments(10) with trickling filters using higher loading rates (3.28 lb BOD/cu yd/day) achieved a removal efficiency of 42 percent as compared to 60-80 percent normally expected from first-stage, high-rate filters using municipal sewage. These experiments indicate that the use of trickling filters with cannery waste is not particularly effective.

Activated Sludge application has been limited to pilot scale studies. Reported efficiencies(16) range up to 97 percent; however, in most cases the operation was hampered by necessarily low BOD loadings, nitrogen and phosphorous deficiencies, and extended aeration periods.

Anaerobic fermentation has a fair amount of application within anaerobic lagoons. A summary of the processes is found in Table III-2(17). It is seen that detention periods range from 4-6 hours to 37 days, with 10 days being a reasonable value. Loadings vary between 0.0096 lb BOD cu ft/day to 0.43 lb BOD/cu ft/day, while BOD removal efficiencies range between 40-95 percent.

Aerobic lagoons have been employed in those areas where land was available at low cost and intermittent odors were not a restricting problem. Most aerobic lagoon data is concerned more with odor control than BOD removal. Aerobic lagoons have been found to operate efficiently when low loading rates and long detention periods (+ 100 days) were coupled with sodium nitrate control(18). Reported efficiencies have been as high as 83-99 percent(19) (20)

SODIUM NITRATE APPLICATION RATES FOR ODOR CONTROL

Type of Waste	$NaNO_3$ Application per 1000 No. 2 Cases (lb)
Beans, green or wax	20
Beans, lima	60
Beets	200
Carrots	200
Corn	200
Peas, early	200
Peas, late	150
Tomatoes	200

7) Sand Filtration: Sand filtration has seen application as a polishing step following chemical precipitation(21) and sedimentation(22). Loading rates ranged from 69 gal/acre/min with an associated BOD removal of 85 percent to 87,000 gal/acre/min resulting in a BOD removal of 15 percent. In all cases, filter clogging was a major problem.

8. Irrigation: Cannery wastes can also be disposed of by spray irrigation. Suitable land acreage nearby is required. It is a satisfactory method that usually can be employed if waste is non-toxic to the vegetation. Its use is primarily limited by the capacity of the spray field to absorb the wastewater. High BOD reductions may be expected as the waste is biologically decomposed within the soil. Some spray irrigation performances are tabulated on the following page.

SPRAY IRRIGATION PERFORMANCE

Product	Pump rate (gpm)	Total Area Sprayed (acres)	Rate of Application (gpm/acre)	Average Application (in/day)	Average Loading	
					(lb BOD/acre)	(lb SS/acre/day)
Tomatoes	1000	5.63	178	2.96	413	364
	550	6.4	86	0.70	155	139
Corn	350	2.28	153.5	3.35	864	500
Asparagus and beans	253	0.9	282	3.5	22.5	356
Tomatoes, corn, and lima beans	430	9.18	43.8	0.375	40.5	14.7
Lima beans	430	6.64	65	0.375	65	46
Cherries	215	2.24	06.5	3.61	807	654

Use of ridge-and-furrow irrigation or absorption beds is limited to soils of relatively high water-absorbing capacity. Permanent pasture grasses are apparently able to handle a heavier organic load than alfalfa. Crop cover will provide as much as 85-90 percent more soil absorption. One type of crop recommended(6) consists of the following mixture:

	(%)
Mammoth Clover -	19
Ladino-Alsac mixture -	25
Alta-fescue -	25
Redtop -	19
Orchard Grass -	12

This mixture is sown at a rate of 16 lb per acre to produce as dense a cover crop as possible at the time of wastewater application.

b. Solid Wastes Disposal: In most plants the solid wastes are a liability to the canner. In urban areas the canner must pay on a weight or volume basis to have the wastes removed from the plant. In some operations almost half the raw tonnage received at the cannery must eventually be handled as solid waste. Because of the lack of economic and technical information concerning by-product potential, the canner or hauler normally disposes of the wastes by the least expensive method available. Often, however, thought and ingenuity has lessened the costs of solid waste disposal and created economical methods of using these wastes, as in the preparation of charcoal briquets from fruit pits.

1) Landfill: The most widely used approach for disposal of solid wastes is by landfill. To maintain a sanitary environment, it is essential that strict control be enforced to ensure against ground water pollution, fly breeding, and odor nuisances.

Of paramount importance is the requirement that an earthen cover be placed over the solid waste within 24 hours. Costs, including hauling, range from $1 to $3 per cu yd of waste. A second method of land disposal involves spreading the waste material in a thin layer over the land surface. It must then be worked into the soil to prevent odor production and fly breeding. Use of this method has been curtailed by the decreasing availability of low cost land.

2) Composting: With proper preparation of screenings and cuttings, including grinding, pH control and nutrient additives, it is possible to compost cannery solid wastes efficiently. Studies(23) (24) indicate that a mixture of two parts of fruit wastes to one part absorbing material, and a moisture content of 65-70 percent, will yield a satisfactory end product.

3) Pressing and Drying: Pressing and drying of citrus wastes have resulted in by-product recovery of citrus feed and citrus syrup. The feed is used for animals, while the syrup is used in cordials, brandies, and fortified wines.

4) Incineration: In a few instances, comparatively dry waste solids have been incinerated. Although no actual data is available on this application of incineration, municipal wastes have been incinerated when the solids content exceeded 35 percent. Partial pre-drying of solids by use of stack gases has been considered to reduce the calculated ignition. Ignition usually takes place at a temperature of 1400°F. Incineration would reduce BOD by close to 100 percent. However, air pollution is a major obstacle to large scale incineration of solid cannery wastes.

5) Wet Oxidation: Combustion via wet oxidation or pressure burning has been used on industrial wastes as well as municipal wastes. BOD removal efficiencies can approach 99 percent. Acceptance of this process has been limited by the high costs.

6) Animal Feed: Disposal of wet waste solids by feeding to animals has been widely practiced in some areas of the country. However, there are many important objections: opposition from residents near the intended site of operation; prohibitive hauling costs; lack of balanced nutrients in fruit wastes; and the seasonal nature of cannery operations. Tomato wastes have been especially useful as animal feed, namely chicken and dog food.

7) City Sewers: From the canner's standpoint, the most convenient method of solid waste disposal would be to discharge to a sewage treatment plant. The obvious disadvantage is the increased loading during the three-month canning season. Appropriate increases would be required in the treatment works.

TABLE III-3

ANAEROBIC FERMENTATION OF CANNING WASTES

Waste	Organic Content (mg/1 BOD)	Process	Loading (1b BOD/cu ft/ day)	Detention Period (days)	Process Efficiency (%)	Comments
Tomato	550	pilot digester	0.0075 .0051 .0006	7.4 9.25 37	80 82 98	
Tomato & Pea	---	lagoon	---	2.5	40	
Tomato	---	lagoon	0.0024 to 0.0099	7.5-10	70	
Pumpkin	---	lagoon		7.5-10	50	
Pea Blancher	30,000 31,000[1]	primary & secondary digesters	0.1 to 0.2	10	90	Mixed with domestic sludge
Peach-Pear and Sewage	360 - 1,200	Bench scale digester	0.11 - 0.43	4.6[2]	50-70	Followed by plain aeration, eff. 90%
Molasses Process Water	37,000 40,000[1]- 70,000	pilot digester	0.19	10	95	No effect noted when BOD: N ratio exceeded 50:1

1. Volatile suspended solids
2. Hours

2. Rates of Adoption

Since 1950, canning of fruits and vegetables has increased at the relatively uniform rate of 2-1/4 percent per year. Predictions made in 1957 based on the expansion of California agriculture indicate an increase of at least 90 percent by the year 2020. Since a large percentage of canned products originates in California, this estimate should be fairly accurate for the industry as a whole. This predicted expansion anticipates an annual growth of approximately 1-1/2 percent per year. In 1967, the Business and Defense Services Administration, U.S. Department of Commerce, prepared projections of the expansion of this industry. These indicate that there will be a relatively uniform growth rate of about 4 percent per year for the next 10 years.

It is anticipated that the rate of adoption of pollution reduction techniques will continue at a rate at least equalling the industry growth rate and possibly exceeding it. The national effort to reduce pollution will create standards for most watercourses in the near future. The rigorous enforcement of these standards will force most of those plants not now providing adequate treatment to either connect to a municipal system or construct efficient facilities.

Industry will continue to improve techniques of water reuse and production line modification, and changeover will reflect the increasing cost of labor, equipment process water, and wastewater disposal and treatment. Emphasis will be on dry, semi-dry, and re-cycled wet processes to the greatest extent possible.

Economic factors, however, largely dictate the adoption of in-plant waste reduction techniques. Each plant management makes decisions based upon its own unique situation, and generally it requires a positive benefit in cost savings or community relations to justify in-plant changes effecting waste reduction.

In past and present practice, the majority of canneries have discharged wastes to municipal sewers. Service charges more often than not were based on hydraulic discharge, and pretreatment consisted only of screening. However, as water quality standards increase and municipal treatment costs go up, there will be greater incentive to shift to industrial treatment utilizing methods specific to the industry's needs. Thus, new canneries will be built to include as part of the normal operation, waste conservation, treatment, and reclamation facilities.

It is possible to list past treatment processes chronologically, but such a survey is misleading because it does not reflect changes in the state-of-the-art or increased sophistication. Instead, the survey would show that practical limitations rather than operational efficiency often dictated the choice of treatment. Facilities were constructed which cost little to build and less to operate. So long as the effluents were acceptable to the community nothing further was required. However, industry leaders recognize the need to upgrade environmental quality,and various waste management systems are being evaluated to develop cost and efficiency parameters.

While automation may lead to a greater emphasis on high rate chemical and biological processes, this is not necessarily the future trend. However, one may assume that modern research and technology will be applied to all operations. Research, development, and demonstration programs are most important to prove the new technology needed for improved food process waste management.

3. Discharge to Municipal Sewerage Systems

The quantity of wastes discharged from canneries to municipal sewerage systems has been increasing in terms of both volume and percentage. This trend is expected to continue for several reasons: establishment and/or relocation of plants in developed industrialized areas where municipal sewerage systems are available; urban growth encircling canneries with subsequent expansion of municipal sewer systems; and increased pressure by regulatory agencies regarding stream pollution. These assumptions are reflected in the following estimate of the percentage of wastes discharged to municipal sewers.

Year	1950	1963	1967	1972	1977	1982
Wastes Discharged to Sewers (%)	50	60	62	65	69	74

Although cannery wastes are amenable to combined treatment with municipal sewage, several problems are encountered in this practice. First, most canneries operate seasonally as noted in Section II E. The sudden and burdensome pollutant load on a municipal treatment plant often reduces the efficiency of that plant. Second, certain cannery processes, such as lye peeling or blanching, produce a slug of hot and/or alkaline waste sufficient to upset physical, chemical, and biological processes at the municipal plant.

These difficulties may be reduced by ambitious water reuse; proper pretreatment, such as adequate screening and equalization; and efficient use of water in plant clean-ups. Proper sewer service charges to discourage flagrant discharge of wastes may improve combined treatment. In certain instances the charges are based on peak instantaneous flow rates and maximum wasteload as well as total volume discharged.

C. By-Product Utilization

In the food processing industry, wastes are largely organic and of a highly bio-degradable nature. However, in a few instances, solid wastes have been sold in adjacent agricultural communities. In particular, tomatoes have been pressed and dehydrated for use as hog or cattle feed. Pea vines, corn husks, and corn cobs have also had limited sales. Citrus peel wastes may be pressed for molasses which can be processed, dried,and sold as cattle feed. It has been reported that installation of flash evaporators to produce the molasses has significantly reduced the wasteload discharged. Certain types of pits and nut shells are being converted to charcoal.

Due to the low value of these by-products, the primary benefit to the cannery at this time is the avoidance of the cost of hauling wastes to a landfill. As the cost of solid waste disposal increases, it is anticipated that new by-products will be developed,but projecting these by-products in terms of wasteloads and volumes would be conjecture.

D. Net Waste Quantities (1963)

The gross waste discharged in 1963 has previously been estimated in Section II A 4 as 370 million lb of BOD, 425 million lb of SS and 395 million lb of TDS. In 1963 it was estimated that 60 percent of the cannery plant waste was discharged to a municipal system and treated by municipal sewage treatment facilities. Most of the waste discharged to a municipal system was pretreated by in-plant screens or some other means of gross solids separation prior to discharge.

Of that waste which is not discharged into municipal sewers, it is estimated that virtually all is treated by some form of gross solids separation prior to discharge; however, only one-third is subjected to complete secondary treatment. This one-third represents approximately 13 percent of the total waste discharged.

Average pollution reduction efficiency for municipal plants in 1963 is estimated as follows: BOD 75 percent, SS 85 percent, and TDS 14 percent. These removal efficiencies include the pretreatment given at the food plant prior to discharge into the sewer.

Average pollution reduction for industry owned and operated secondary treatment facilities in 1963 is estimated as follows: BOD - 80 percent, SS - 90 percent, and TDS - 30 percent. The reason behind the higher reduction for industry operated plants is the wide prevalence of spray irrigation and evaporation/percolation ponds which essentially keep 100 percent of the organic waste out of the nation's watercourses.

Estimated net wastes reaching watercourses in 1963 are noted in Table III-4.

E. Projected Net Wasteload

The net waste quantities are estimated in Table III-4. These quantities were calculated based on the gross wasteload generated by the canneries before any treatment within the plant, the projected reduction efficiencies within the canneries and municipal treatment facilities, and the projected percentage of wastes discharged to municipal treatment works.

TABLE III-4

PROJECTED NET WASTELOADS

Year	Waste	Gross produced by plants (million lb)	Removal (%)	Net quantity reaching watercourses (million lb)
1963	BOD	370	57	160
	SS	425	63	160
	TDS	395	12	350
1968	BOD	435	64	155
	SS	500	73	135
	TDS	465	19	375
1969	BOD	445	65	155
	SS	510	74	135
	TDS	475	19	385
1970	BOD	455	66	155
	SS	520	75	130
	TDS	485	19	390
1971	BOD	460	67	150
	SS	525	76	125
	TDS	490	19	395
1972	BOD	465	68	150
	SS	535	77	125
	TDS	495	19	400
1977	BOD	490	73	130
	SS	565	82	100
	TDS	525	21	415

IV. COST INFORMATION

A. Existing Facilities Costs

It is estimated that in 1966 virtually all of the nation's canneries operated and maintained at least some form of gross solids separation facility, such as screens, to pretreat the waste prior to discharge. An estimated 13 percent of the plants provided further secondary type treatment such as spray irrigation, percolation/evaporation ponds, etc. It is estimated that the 1966 replacement value of these industry owned and operated waste treatment facilities was about $18 million, and that the operating and maintenance costs were in the order of $3 million. These estimates exclude the costs of in-plant water conservation, reuse, and reclamation.

It must be noted that the above values are for industry owned and operated waste effluent facilities only. It is estimated that in 1960 approximately 62 percent of the waste was discharged into and treated by municipal systems. Since industry pays taxes and surcharges to support these facilities, the true industry cost exceeds the foregoing amounts. The replacement value of that portion of municipal treatment facilities construction attributable to this industry's waste is estimated to be $60 million. On the same basis, the annual operating and maintenance cost is estimated at $10 million.

The total 1966 waste reduction costs (exclusive of sewage collection system costs such as municipal sewers) are estimated to be:

Facilities replacement value - $78 million
Operation and maintenance cost - $13 million

B. Processing and Treatment Costs

This portion of the survey analyzes costs involved in subprocesses and end of the line treatment. Tables IV-1 through IV-9 break down costs for various sizes of plants and levels of technology. Because of the wide ranges in the information feedback from the industry, cost ranges have been used in the tables. Table IV-10 gives estimated cost data on the entire industry and relates cost of waste treatment to cost of production. We believe this latter table gives a much more accurate picture of the present industry cost situation than do the tables preceding it.

New machinery for subprocesses is purchased by the industry primarily on the basis of increasing production efficiency and product quality. The pollution load produced by the subprocess has been a secondary consideration. However, canners and frozen food processors are gradually becoming more aware of the problems and costs associated with water use and wasteload discharge.

The end of the line waste treatment may have little relationship to the technology of the process that created the waste or the size of the plant; i.e., an older technology plant may have an efficient waste treatment facility, and a modern, efficient plant may have no waste treatment facility at all. With few exceptions, the end of the line treatment is selected primarily on the basis of requirements imposed by regulatory agencies responsible for the watercourses being affected.

The following estimated costs are for plants incorporating pure states of technology; i.e., completely old, completely prevalent, completely advanced. Few such plants exist. Most are mixtures of varied subprocess technologies since they have been modernized in stages over a relatively long period of time.

The following definitions are necessary for proper interpretation of the tables.

Old technology - that technology new in 1950

Prevalent technology - that technology new in 1963

Newer technology - that technology new in 1967

Small plant - processing 2,000 cases per day

Medium plant - processing 10,000 cases per day

Large plant - processing 30,000 cases per day

Capital cost - equivalent 1966 cost

Annual operating and maintenance expenditures - equivalent 1966 cost

Economic life - the length of time the machine or structure can be expected to compete with advancing technology, essentially the length of time before economic obsolescence. This will vary greatly depending upon the nature of the produce, dynamics of industry growth, region, etc.

TABLE IV-1 COSTS - SMALL PLANT (2000 cases/day) OLD TECHNOLOGY (1950)

Item	Capital Costs	Annual Operating & Maintenance Expenditures	Economic Life
	($1000)	($1000)	(Years)
Subprocesses			
Washing	10 - 20	10 - 20	7
Sorting, Slicing, etc.	10 - 20	70 - 100	7
Blanching and/or Peeling	10 - 30	15 - 20	7
Exhausting of Cans	10 - 30	5 - 10	7
Processing	30 - 60	70 - 100	7
Cooling of Cans	10 - 20	5 - 10	7
Plant Clean-up	-	15 - 20	-
Rest of Plant	50 - 80	10 - 25	10
Total	130 - 260	200 - 305	
End of Line Treatment			
Screening	1 - 5	0.3 - 0.8	10
Sedimentation	2 - 6	0.4 - 1	10
Flotation	3 - 8	0.5 - 1.3	10
Chemical Precipitation	3 - 9	1.3 - 5	10
Activated Sludge	11 - 30	1.8 - 5	10
Trickling Filters	9 - 20	1.3 - 3	10
Lagoons	1 - 3	0.1 - 0.3	10
Spray Irrigation	1 - 6	0.5 - 1.3	10
Solid Waste Disposal	-	0.4 - 2.5	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate conversion factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

These assumptions were considered necessary to comply with the contract while permitting comparison of waste treatment costs achieved first, by lesser waste volume and strength generated by a plant per unit of product and second, by increased efficiency in certain end of the line waste treatment processes.

TABLE IV-2 COSTS - MEDIUM PLANT (10,000 cases/day)
OLD TECHNOLOGY (1950)

Item	Capital Costs	Annual Operating & Maintenance Expenditures	Economic Life
	($1000)	($1000)	(Years)
Subprocesses			
Washing	50 - 70	40 - 80	6
Sorting,Slicing,etc.	50 - 100	300 - 350	6
Blanching and/or Peeling	60 - 120	50 - 70	6
Exhausting of Cans	40 - 80	10 - 20	6
Processing	150 - 250	250 - 350	6
Cooling of Cans	40 - 80	10 - 20	6
Plant Clean-up	-	30 - 40	6
Rest of Plant	300 - 400	70 - 150	13
Total	690 -1100	760 -1080	
End of Line Treatment			
Screening	4 - 20	1 - 2	10
Sedimentation	9 - 25	1.5- 4	10
Flotation	11 - 30	2 - 5	10
Chemical Precipitation	11 - 35	5 - 20	10
Activated Sludge	45 - 120	7 - 20	10
Trickling Filters	35 - 80	5 - 12	10
Lagoons	3 - 10	0.5- 1	10
Spray Irrigation	5 - 25	2 - 5	10
Solid Waste Disposal	-	1.5- 10	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate conversion factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

These assumptions were considered necessary to comply with the contract while permitting comparison of waste treatment costs achieved first, by lesser waste volume and strength generated by a plant per unit of product and second, by increased efficiency in certain end of the line waste treatment processes.

TABLE IV-3 COSTS - LARGE PLANT (30,000 cases/day) OLD TECHNOLOGY (1950)

Item	Capital Costs	Annual Operating & Maintenance Expenditures	Economic Life
	($1000)	($1000)	(Years)
Subprocesses			
Washing	75 - 170	100 - 200	5
Sorting,Slicing,etc.	150 - 250	600 - 800	5
Blanching and/or Peeling	150 - 350	110 - 160	5
Exhausting of Cans	100 - 200	30 - 50	5
Processing	300 - 500	550 - 650	5
Cooling of Cans	100 - 200	30 - 50	5
Plant Clean-up	-	100 - 150	-
Rest of Plant	650 -1300	200 - 400	15
Total	1525 -2970	1720 -2460	
End of Line Treatment			
Screening	8.4 - 42	2 - 4.2	10
Sedimentation	19 - 53	3.2- 8.4	10
Flotation	23 - 63	4.2-10.5	10
Chemical Precipitation	23 - 74	10.5-42	10
Activated Sludge	95 - 252	15 -42	10
Trickling Filters	74 - 168	10.5-25	10
Lagoons	6.3 - 21	1 - 2	10
Spray Irrigation	10.5 - 53	4.2-10.5	10
Solid Waste Disposal	-	3.2-21	

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate conversion factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

These assumptions were considered necessary to comply with the contract while permitting comparison of waste treatment costs achieved first, by lesser waste volume and strength generated by a plant per unit of product and second, by increased efficiency in certain end of the line waste treatment processes.

TABLE IV-4 COSTS-SMALL PLANT (2000 equivalent cases/day), PREVALENT TECHNOLOGY (1963)

Item	Capital Costs	Annual Operating & Maintenance Expenditures	Economic Life
	($1000)	($1000)	(Years)
Subprocesses			
Washing	10 - 25	10 - 20	6
Sorting,Slicing,etc.	10 - 25	65 - 90	6
Blanching and/or Peeling	15 - 35	15 - 20	6
Exhausting of Cans	15 - 35	5 - 10	6
Processing	35 - 70	65 - 90	6
Cooling of Cans	15 - 30	5 - 10	6
Plant Clean-up	-	15 - 20	-
Rest of Plant	80 - 100	10 - 20	12
Total	180 - 320	190 - 280	
End of Line Treatment			
Screening	0.8 - 3.8	0.2 0.4	10
Sedimentation	1.7 - 4.7	0.3 - 0.8	10
Flotation	2 - 5.7	0.4 - 1	10
Chemical Precipitation	2 - 6.6	1 - 3.8	10
Activated Sludge	8.5 - 23	1.3 - 3.8	10
Trickling Filters	6.6 - 15	1 - 2.3	10
Lagoons	0.6 - 2	0.1 - 0.2	10
Spray Irrigation	1 - 4.7	9.4 - 1	10
Solid Waste Disposal	-	0.3 - 2	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate conversion factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

These assumptions were considered necessary to comply with the contract while permitting comparison of waste treatment costs achieved first, by lesser waste volume and strength generated by a plant per unit of product and second, by increased efficiency in certain end of the line waste treatment processes.

TABLE IV-5 COSTS - MEDIUM PLANT (10,000 cases/day), PREVALENT TECHNOLOGY (1963)

Item	Capital Costs	Annual Operating & Maintenance Expenditures	Economic Life
	($1000)	($1000)	(Years)
Subprocesses			
Washing	60 - 90	40 - 80	5
Sorting,Slicing,etc.	60 - 120	275 - 325	5
Blanching and/or Peeling	80 - 160	40 - 60	5
Exhausting of Cans	50 - 100	10 - 20	5
Processing	200 - 300	225 - 325	5
Cooling of Cans	60 - 120	10 - 20	5
Plant Clean-up	-	30 - 40	-
Rest of Plant	475 - 575	70 - 150	10
Total	985 - 1469	700 - 1020	
End of Line Treatment			
Screening	3.2 - 16	0.8 - 1.6	10
Sedimentation	7.2 - 20	1.2 - 3.2	10
Flotation	8.8 - 24	1.6 - 4	10
Chemical Precipitation	8.8 - 28	4 - 16	10
Activated Sludge	36 - 96	5.6 - 16	10
Trickling Filters	28 - 64	4 - 9.6	10
Lagoons	2.4 - 8	0.4 - 0.8	10
Spray Irrigation	4 - 20	1.6 - 4	10
Solid Waste Disposal	-	1.2 - 8	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate conversion factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

These assumptions were considered necessary to comply with the contract while permitting comparison of waste treatment costs achieved first, by lesser waste volume and strength generated by a plant per unit of product and second, by increased efficiency in certain end of the line waste treatment processes.

TABLE IV-6 COSTS - MEDIUM PLANT (10,000 cases/day), NEW TECHNOLOGY (1967)

Item	Capital Costs	Annual Operating & Maintenance Expenditures	Economic Life
	($1000)	($1000)	(Years)
Subprocesses			
Washing	100 - 220	100 - 200	4
Sorting,Slicing,etc.	190 - 320	500 - 700	4
Blanching and/or Peeling	190 - 450	110 - 160	4
Exhausting of Cans	130 - 260	30 - 50	4
Processing	400 - 650	550 - 650	4
Cooling of Cans	130 - 260	30 - 50	4
Plant Clean-up	-	100 - 150	-
Rest of Plant	1000 - 2000	200 - 400	15
Total	2140 - 4360	1620 - 2360	
End of Line Treatment			
Screening	8 - 42	.2 - 4.2	10
Sedimentation	19 - 53	3.2 - 8.4	10
Flotation	23 - 63	4.2 - 10.5	10
Chemical Precipitation	23 - 74	10.5 - 42	10
Activated Sludge	95 - 252	15 - 42	10
Trickling Filters	74 - 168	10.5 - 25	10
Lagoons	6.3 - 21	1 - 2	10
Spray Irrigation	10.5 - 53	4.2 - 10.5	10
Solid Waste Disposal	-	3.2 - 21	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate conversion factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

These assumptions were considered necessary to comply with the contract while permitting comparison of waste treatment costs achieved first, by lesser waste volume and strength generated by a plant per unit of product and second, by increased efficiency in certain end of the line waste treatment processes.

TABLE IV-7 COSTS - SMALL PLANT (2000 cases/day), NEW TECHNOLOGY (1967)

Item	Capital Costs	Annual Operating & Maintenance Expenditures	Economic Life
	($1000)	($1000)	(Years)
Subprocesses			
Washing	20 - 35	10 - 20	5
Sorting,Slicing,etc.	25 - 40	60 - 85	5
Blanching and/or Peeling	20 - 30	15 - 20	5
Exhausting of Cans	15 - 35	5 - 10	5
Processing	40 - 60	65 - 90	5
Cooling of Cans	15 - 30	5 - 10	5
Plant Clean-up	-	15 - 20	-
Rest of Plant	100 - 150	15 - 25	15
Total	235 - 380	190 - 280	
End of Line Treatment			
Screening	0.6 - 3	0.2 - 0.3	10
Sedimentation	1.3 - 4	0.2 - 0.6	10
Flotation	1.6 - 5	0.3 - 0.8	10
Chemical Precipitation	1.6 - 5	0.8 - 3	10
Activated Sludge	7 - 18	1 - 3	10
Trickling Filters	5 - 12	1 - 2	10
Lagoons	0.4 - 1.5	0.1 - 0.2	10
Spray Irrigation	0.7 - 4	0.2 - 1.5	10
Solid Waste Disposal	-	0.2 - 1.5	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate conversion factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

These assumptions were considered necessary to comply with the contract while permitting comparison of waste treatment costs achieved first, by lesser waste volume and strength generated by a plant per unit of product and second, by increased efficiency in certain end of the line waste treatment processes.

TABLE IV-8 COSTS - MEDIUM PLANT (10,000 cases/day), NEW TECHNOLOGY (1967)

Item	Capital Costs	Annual Operating & Maintenance Expenditures	Economic Life
	($1000)	($1000)	(Years)
Subprocesses			
Washing	60 - 90	40 - 80	5
Sorting, Slicing, etc.	100 - 200	250 - 300	5
Blanching and/or Peeling	90 - 180	40 - 60	5
Exhausting of Cans	50 - 100	10 - 20	5
Processing	220 - 320	210 - 290	5
Cooling of Cans	60 - 120	10 - 20	5
Plant Clean-up	-	30 - 40	-
Rest of Plant	575 - 700	60 - 140	15
Total	1155 -1710	650 - 950	
End of Line Treatment			
Screening	2.7 - 13	0.7 - 1.3	10
Sedimentation	6 - 17	1 - 2.7	10
Flotation	7.4 - 20	1.3 - 3.4	10
Chemical Precipitation	7.4 - 24	3.4 -13	15
Activated Sludge	30 - 81	4.7 -13	10
Trickling Filters	23 - 54	3.4 - 8	10
Lagoons	2 - 7	0.3 - 0.7	10
Spray Irrigation	3.4 - 17	1.3 - 3.4	10
Solid Waste Disposal	-	1 - 6.7	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate conversion factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

These assumptions were considered necessary to comply with the contract while permitting comparison of waste treatment costs achieved first, by lesser waste volume and strength generated by a plant per unit of product and second, by increased efficiency in certain end of the line waste treatment processes.

TABLE IV-9 COSTS - LARGE PLANT (30,000 cases/day), NEW TECHNOLOGY (1967)

Item	Capital Costs	Annual Operating & Maintenance Expenditures	Economic Life
	($1000)	($1000)	(Years)
Subprocesses			
Washing	120 - 240	75 - 150	4
Sorting,Slicing,etc.	300 - 500	400 - 700	4
Blanching and/or Peeling	200 - 400	110 - 160	4
Exhausting of Cans	140 - 270	30 - 50	4
Processing	400 - 700	500 - 620	4
Cooling of Cans	130 - 260	30 - 50	4
Plant Clean-up	-	90 - 140	-
Rest of Plant	1300 - 2800	200 - 400	-
Total	2590 - 5170	1435 - 2270	
End of Line Treatment			
Screening	6.3 - 32	1.6 - 3.2	10
Sedimentation	14 - 40	2.4 - 6.4	10
Flotation	17 - 48	3.2 - 8	10
Chemical Precipitation	17 - 55	8 - 32	10
Activated Sludge	71 - 190	11 - 32	10
Trickling Filters	55 - 127	8 - 19	10
Lagoons	4.7 - 16	0.8 - 1.6	10
Spray Irrigation	8 - 40	3.2 - 8	10
Solid Waste Disposal	-	2.4 - 16	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate conversion factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

These assumptions were considered necessary to comply with the contract while permitting comparison of waste treatment costs achieved first, by lesser waste volume and strength generated by a plant per unit of product and second, by increased efficiency in certain end of the line waste treatment processes.

TABLE IV-10

SUMMARY OF PRODUCTION AND WASTE TREATMENT COSTS

CANNED FRUITS AND VEGETABLES

Item	Quantity
Total production	589 million equivalent cases
Total value added in manufacture*	$1,030 million
Average unit value added in manufacture	$1.75 / equivalent case
Estimated replacement value of waste reduction facilities **	$78 million
Annual amortized cost of facilities at 7% and 10 yr life **	$11.5 million
Estimated annual waste reduction operating and maintenance cost **	$13 million
Average industry cost of waste treatment per unit of production	$0.041 / equivalent case
Total waste reduction costs as percent of total production cost	2.35 percent

* From the Business and Defense Services Administration, U.S. Department of Commerce, 1967.

** Estimated replacement value, estimated amortization, and estimated annual operating costs include an estimate of the cost of municipal treatment facilities attributable to this industry's wastes.

Industrial Waste Profile

Frozen Fruits and Vegetables - SIC 2037

U. S. Department of the Interior
Federal Water Pollution Control Administration
I.W.P. No. 4 - Frozen Fruits and Vegetables

INDUSTRIAL WASTE PROFILE STUDIES

SIC NO. 2037, FROZEN FRUIT AND VEGETABLE INDUSTRY

INTRODUCTION

There are approximately 1150* frozen food processing plants in the United States. They produce almost all of the basic frozen food items, both individually and in combinations. The 1966 food pack(2) included 664 million lb of fruits and berries, 77 million gal of juice concentrates (excluding lemon juice and lemonade), and 3459 million lb of vegetables. The 1966 retail value of this pack approaches $3 billion(1).

For many years information concerning the frozen food industry has been limited primarily to incidental data contained in the canning industry literature. Because the cannery industry is larger, older, and better organized than the frozen food industry, the latter has received little comprehensive study. An effort should be made to rectify this situation because of the unique problems and rapid growth rate of the frozen food industry. Table I depicts this growth from 1950 to 1966 in terms of lb of product processed, number of cases packed, and retail value of the finished product. To facilitate comparison, frozen food product quantities have been converted to their equivalent in terms of canned food cases containing 24 No. 303 cans.

Labor saving specialty foods, mixes, TV dinners and pre-cooked decorative frozen foods are becoming increasingly popular for household and commercial consumption. Very little data is available regarding pollution from these segments of the industry.

* Approximately 650 of these plants process fruits and vegetables.

TABLE I

FROZEN FOOD AND VEGETABLE PACK

Year	Per Million	Frozen Vegetables	Frozen Fruit	Frozen Juices[3]
1950	wt, lb	587	472	907
	equiv.cases of #303	37[2]	29[2]	38
	retail value $	N.A.	N.A.	N.A.
1954	wt, lb	975	523	2440
	equiv. cases of #303	61[2]	33[2]	102
	retail value $	172	260	-[4]
1963	wt, lb	2322	620	1810[5]
	equiv. cases of #303	145	39	76
	retail value $	396	436	-[4]
1965[1] 1966	wt, lb	3459	664	2620[5]
	equiv. cases of #303	216[2]	42[2]	97
	retail value $	N.A.	N.A.	N.A.

1. 1966 pack statistics except where the latest available information was 1965.
2. At 0.0625 cases of #303 cans/lb (16 lb/case based on 1.5 conversion factor from frozen weight to canned weight.
3. Reconstituted and based on a weight of 8.5 lb/gal; exclusive of berry purees.
4. Included in frozen fruit.
5. Exclusive of lemon and lemonade concentrate.

INDUSTRIAL WASTE PROFILE STUDIES
FROZEN FRUITS AND VEGETABLES

SIC 2037

I. PROCESSES AND WASTES

A. Fundamental Industry Processes

Due to the diverse nature of products handled by this industry, coupled with the 1150 plants producing a variety of frozen foods, a multitude of process schemes could be described. Each frozen food processing plant is probably unique in its in-house process. However, for the purposes ot this report, processes will be generalized into the following categories:

1. Preliminary Cleaning and Preparation
2. Freezing of Juices
3. Processing of Frozen Fruits
4. Processing of Frozen Vegetables

Meat and fish processing are not included in this study, nor is the freezing of prepared foods and soups.

1. Preliminary Cleaning and Preparation

The preliminary cleaning and preparation required for raw fruits and vegetables to be frozen is essentially the same as that described for canning (Section I A 1, pages 10 - 13). However, these preliminary operations plus plant cleaning can use up to 90 percent of the process water (exclusive of freezing system water) used by the frozen food plant, and they normally contribute the major portion of the pollution associated with the overall process.

2. Juices - Frozen

In general, the methods employed in the preparation of fruit juices for freezing differ little from those used in the manufacture of fruit juices for flash pasteurization (see Section I A 3, pages 14 - 16).

The principal exception is that the juice is always concentrated, and most of the water removed from the raw product is discharged to waste. Since the vacuum evaporators are not 100 percent efficient, this waste has a fairly high organic pollution loading.

3. Freezing of Fruits: In the freezing of fruits and vegetables, the preliminary processes are very similar to those of canning. The wastes produced are also quite similar. The flavor and color of many varieties of fruit can be well preserved by freezing, but a change in texture always occurs. A pronounced characteristic flavor, attractive color, and good texture should

be retained after defrosting. Most frequently, it is the texture change which makes a variety unsuitable. Since soil and climate affect fruits' characteristics for freezing, the area of the United States in which it is grown will also affect its suitability.

Quick Freezing Methods for fruits in the United States began about 1929 on a commercial scale. Early methods used immersion of the product in brine, or freezing of one side of the product only. Neither was satisfactory for frozen fruits. In 1929, a Birdseye belt freezer was installed in the Ray-Maling plant at Billsboro, Oregon. This process eliminated the danger of spoilage due to bacteria, yeasts, and molds during freezing of fruit and also resulted in a somewhat improved texture. On the other hand, the quick freezing of a fruit packed in syrup or with sugar immediately after packaging did not allow the sugar to penetrate sufficiently into the fruit. For this reason, processors have found it beneficial to hold fruits packed with sugar or syrup at a temperature just above freezing for 1 - 2 hr prior to quick freezing.

Although the untreated fruits in many instances are greatly changed by freezing and thawing, comminuted fruits such as pulped fruit and fruit juices may be preserved by freezing for considerable periods of time without marked change either in flavor or color. Pulping a fruit or converting it into juice greatly reduces the exposure of the product to air, and thus largely eliminates oxidation during freezing, storage, and thawing. A similar effect may be obtained by freezing fruits under plain sugar syrup or under syrup made by dissolving sugar in juice.

5. Freezing of Vegetables: Until 1928 it was believed that freezing ruined vegetables since accidentally frozen vegetables spoiled almost immediately after thawing, and were unpalatable when cooked. However, in 1929, both Joslyn and Cruess concluded independently that it was necessary to blanch vegetables before freezing. They recommended blanching with steam in preference to hot water. Blanching stops the enzymatic degradation of vegetables which occurs after harvesting because of respiration, reduces total bacteria count, and markedly retards the rate of loss of vitamins A, B_1, and C during storage.

Water blanching is often carried out in boiling water; sometimes water as cool as 180°F is used. Hot sugar and acid solutions have been recommended for blanching certain products but are not commonly used. Steam is ordinarily used at atmospheric pressure. The inactivation of the enzymes catalase and peroxidase is the prime objective in blanching. In general, there is a critical temperature range for each vegetable at which color, flavor, and texture is most benefited by heating. The size of the vegetable is also a factor in determining the temperature and length of time of blanching. For example, corn on the cob requires a longer inactivation period than peas.

The general procedures recommended by Joslyn and Cruess in 1929, before the advent of commercial freezing of vegetables, were still used after 1957. The only difference is that after 1957 the blanched vegetables were packed in cartons without covering with brine as suggested by Joslyn and Cruess. Vegetables are almost invariably prepared for cooking before being frozen to preserve their crispness and valuable juices.

Most vegetables deteriorate very rapidly after harvest, especially if allowed to stand in a warm place. Therefore, they are normally prepared for freezing, or chilled at 40°F or lower, immediately.

Furthermore, since warm vegetables lose flavor, vitamins, and color very rapidly, they are normally cooled in very cold running water directly after scalding.

TABLE I-1

TYPICAL EXAMPLES OF VEGETABLE FREEZING PROCESSES

Product	Processes
Artichokes	Blanched 7 min in boiling 0.7 percent citric acid Cooled in water Drained Packed in moisture-proof packages Stored in freezing chamber at -40°F for 4 hr
Asparagus	Steam blanched in a steam chamber about 30 ft long for about 3½ to 5 min Cooled by water sprays Packed in moisture-proof carton Packed in either a multiple freezer or on racks in a cold air blast at -20°F
Baby Lima Beans	Blanched in water at 212°F for 2½ min Cooled by a stream of cold water Washed to remove brine Packed in cartons Frozen in an air blast at -10° to -15°F Stored at 0°F
Beets (small)	Steam blanched for 2½ min in boiling water Cooled in running water Peeled in a mechanical peeler Washed Drained Quick Frozen
Beets (large)	Frozen after cooking
Broccoli	Steam blanched 3-5 min Cooled in sprays or by immersion in water in an endless chain Packed in cartons Frozen in air blast freezer on coils or on plates
Corn (cut)	Steam blanched at atmospheric pressure 2-4 min Cleaned and cooled by water to remove bits of silk, husk, tiny particles of corn Packed Frozen in multiple freezer or trays placed on racks

TYPICAL EXAMPLES OF VEGETABLE FREEZING PROCESSES (Cont'd)

Product	Processes
Peas	Conventional hot water (most popular) or steam (atmospheric blanching for 50-60 sec between 185°F and 205°F) Some recirculation of hot water is practiced Cooled in water flumes Washed to remove salt Packaged

TYPICAL EXAMPLES OF FRUIT FREEZING PROCESSES

Peaches	Anti-oxidant fortified syrup added after peeling and cooling Packed in cartons Held at a temperature just above freezing for 1 or 2 hours to allow syrup to penetrate fruit Quick frozen
Strawberries	Sugar syrup or dry sugar added Packed in cartons or bags Quick frozen

B. Significant Pollutants

Significant pollutants in this industry arise from the following operations:

1. Initial Preparation
2. Blanching
3. Hot Lye Peeling
4. Sorting, Slicing, Cutting, Blending, etc.
5. Processing
6. Washing (several washes are used in most plants)
7. Plant Clean-up

The combined wastes have the objectionable characteristics of high BOD, TDS, and suspended solids. The initial preparation, blanching, and peeling operations supply particularly concentrated wastes.

The effect of these pollutants on the receiving water is similar to that of cannery wastes as described in Section I B, pp. 16-17. However, the frozen food industry generally produces a more dilute waste since the same amount of pollution is contained in about twice the volume. In those cases where the waste is discharged directly into the receiving stream, the initial dilution would be of benefit.

C. Process Water Reuse - 1964

The following is a tabulation(3) of the 1963 water intake, water use and reuse, and waste discharge for frozen fruit and vegetable processing plants throughout the nation. It should be noted this tabulation does not include plants using less than 20 MG/yr.

Item	Water Quantity in billion gal/yr	Percentage of Intake Quantity
Water Intake	34	100
Process	15	44
Cooling, Condensing	16	47
Boiler Feed, Sanitary Service, & Other	3	9
Recirculated Water	15	44
Consumption	1	3
Discharge	33	97

Only 99 of the frozen food processing plants reported in the 1963 Census of Manufacturers. Based on other statistics from the census, it was calculated that the industry's total water intake and waste discharge were as follows:

	Quantity in billion gal/yr	
	Intake	Discharge
Frozen fruits and Vegetables	36	35

Comparing these water use statistics with those of the canning industry shows that the frozen food industry uses almost twice as much water per unit of production and that much of this additional water is used in the cooling and condensing equipment. In addition, less water is consumed in process, and a higher percentage of the intake water is eventually discharged.

The industry estimates that in 1966 approximately 50 percent of process water was reused at least once. In many instances water from certain processes was reused many times.

D. Subprocess Trends

Table I-2 describes the predominating subprocess mixes for the frozen fruit and vegetable industry. Many plants do not use all of the subprocesses shown and others use several methods to accomplish one subprocess. Some of the subprocesses are characteristic of only one segment of the industry. Totals for any given subprocess may increase or decrease due to the change in size of the segment of the industry using the given subprocess relative to the rest of the industry.

These processes were studied by thoroughly reviewing available literature, interviewing key personnel within the industry, observing operations in several representative plants, and analyzing production quantities given in the 1967 Almanac of the Canning, Freezing, and Preserving Industries.(5)

The tables consist of three sections as follows:

A) Initial Preparation
B) Frozen Fruits and Vegetables
C) Frozen Fruit Juices

TABLE I-2 SUBPROCESS TRENDS

Fundamental Process and Subprocesses	Percentage of Total Plants				
	1950	1963	1967	1972	1982
SECTION A - INITIAL PREPARATION					
Pre-Cleaning					
1. Spray Wash, Rinse	60	70	70	70	70
2. Detergent Wash & Rinse	10	5	5	10	10
3. Water Soak Only	5	5	0	0	-
4. Water & Rinse Bath	10	10	5	0	0
5. Brine	5	5	5	5	5
6. Flume	10	5	10	10	10
7. Dry Cleaning	-	-	5	5	10
Sorting					
1. Mechanical					
a. Screening (size grading)	10	20	20	25	35
b. Flotation	10	15	20	25	25
2. Hand	95	85	85	75	70
Trimming					
1. Hand	35	30	25	20	15
2. Silking & Husking	5	5	5	5	5
3. Mechanical	15	15	20	25	30
Coring & Pitting					
1. Hand	10	5	5	3	2
2. Mechanical	20	25	25	27	28
3. Kernel Cutter	5	5	5	5	5
Cutting					
1. Slicing	25	25	25	25	25
2. Dicing	25	25	25	25	25
3. Halving	15	15	15	15	15
4. Snipping	20	20	20	20	20
Peeling					
1. Steam Scalding	10	5	5	5	5
2. Hot Lye	10	15	15	15	15
3. Abrasion	5	5	5	5	5
4. Mechanical Knives					

Fundamental Process and Subprocesses	Percentage of Total Plants				
	1950	1963	1967	1972	1982
SECTION A (cont'd)					
Grading & Inspection					
1. Eye	100	100	98	95	85
2. Photo-Med. Color	-	-	2	5	15
Transport					
1. Primary Flume (Water)	45	60	65	70	70
2. Conveyer Belt	75	80	85	90	95
3. Cart/Truck/Hand	10	8	6	3	2
Product Waste Disposal					
1. Floor Disposal	10	5	2	1	-
2. In-process Bin Collection	30	20	13	9	5
3. Conveyors	20	10	10	20	30
4. Floor Gutters & Flumes	100	100	100	100	100
Plant Clean-up	100	100	100	100	100
SECTION B- FROZEN FRUITS & VEGETABLES					
Blanching					
1. Steam	40	35	35	40	45
2. Hot Water	55	55	55	50	40
3. Brine in Vac./Press.	5	10	10	10	5
Cooling					
1. Running Rinse	50	50	45	40	30
2. Spray Rinse	50	50	55	60	70
Solid Waste Handling					
1. Floor Disposal	5	3	1	-	-
2. In-process Bin Collection	5	3	1	-	-
3. Conveyors	10	14	18	25	30
4. Floor Gutters & Flumes	80	80	80	75	70
Plant Clean-up	100	100	100	100	100

Fundamental Process and Subprocesses	Percentage of Total Plants				
	1950	1963	1967	1972	1982
SECTION C - FROZEN FRUIT JUICES					
Extraction					
1. Crush/Press	10	10	10	10	10
2. Reaming	25	25	25	25	25
3. Pulping	65	65	65	65	65
Screening					
1. Mesh Screen	3	3	3	3	3
2. Centrifuge	2	2	2	2	2
De-Oil					
1. Heating in Vac.	7	12	15	16	18
De-Aerate	1	1	1	1	1
Clarification					
1. Gelatin & Tannin	5	3	2	1	1
2. Pectic Enzyme	8	13	15	17	17
3. Flash Heating	5	2	1	-	-
4. Freezing & Thawing	2	2	2	2	2
Pasteurization					
1. Pasteurization Only	90	80	80	75	70
2. Pasteurization & Concentration	10	20	20	25	30
Solid Waste Handling					
1. Floor Disposal	10	5	2	-	-
2. In-process Bin Collection	25	15	10	10	5
3. Conveyors	20	15	18	20	30
4. Floor Gutters & Flumes	45	65	70	70	65
Plant Clean-up	100	100	100	100	100

E. Waste Control Problems

The waste control problems in the frozen food industry are similar to those in the canning industry (see Section I E p. 25).

F. Subprocess Technologies

The discussion of subprocess technologies found under canning (see Section I F page 25) is also applicable to the frozen food industry. The principal difference is the freezing step which does not produce significant pollution.

There is an excellent discussion of relative plant sizes found in "Organization and Competition in the Fruit and Vegetable Industry", Technical Study No. 4, National Commission on Food Marketing, June 1966. It reveals that the average plant output in 1963 was 9.5 million pounds. It also shows that the Southeast and Pacific regions have predominantly large plants; the Northeast, small plants; and the Midwest, medium size plants. An arbitrary classification of frozen food plant sizes is:

Small plant - annual output less than 8.5 million lbs
Medium plant - annual output of 8.5 to 25 million lbs
Large plant - annual output of over 25 million lbs

The estimated percentage of plants falling into each classification is:

Small - 50 percent, Medium - 25 percent, Large - 25 percent

The frozen food industry has experienced such phenomenal growth in the last 15 years that any attempt to relate plant size to technology level would be meaningless. It can safely be said that the great majority of the plants would be classified as prevelant or new in technology level.

II. GROSS WASTE QUANTITIES

A. Daily Waste Quantities

Data describing individual waste streams from each process in a fictitious average frozen food processing plant are reported in Table II-1. It will be noted that the pollution generated is slightly less than for an equivalent cannery except for volume which is considerably higher.

TABLE II-1 DAILY WASTE QUANTITIES

Subprocesses of Prevalent Technology	Wasteload, Lb/Day for Average Size Plant Producing 8.25 Tons/Day			Wastewater Volume (mgd)
	BOD	SS	TDS	
Washing	500 - 3,000	500- 4,000	300 - 1,500	.150 - .500
Belt Conveyor	30 - 100	100- 200	30 - 100	.020 - .100
Sorting, Pitting, Slicing, etc.	50 - 600	150- 700	100 - 500	.020 - .150
Blanching and/or Peeling	1500 - 4,000	1,000- 4,000	2,000 - 4,000	.150 -1.15
Plant Cleanup	320 - 1,200	300- 1,500	230 - 1,000	.060 - .200
TOTAL	2,400 - 8,900	2,050- 10,400	2,660 - 7,100	.400 -2.10
AVERAGE	6,200	6,200	5,000	1,250

NOTES:

1. Normal season and period of major waste discharge averages 3 months per year.

2. Fluming volumes and wasteloads are included with their associated subprocesses.

TABLE II-1 DAILY WASTE QUANTITIES

Subprocesses of Newer Technology	Wasteload, Lb/Day for Average Size Plant Producing 8.25 Tons/Day			Wastewater Volume (mgd)
	BOD	SS	TDS	
High Pressure-Low Volume Wash sprays following Mechanical Harvesting	500 - 3,000	200 - 5,000	300 - 1,500	.130 - .400
Belt Conveyor	20 - 100	20 - 200	30 - 60	.015 - .075
Mechanical Sorting, Trimming Pitting, etc.	50 600	100 - 700	80 - 400	.010 - .125
Blanching and/or Peeling	1,500 - 4,000	900 - 4,000	2,000 - 4,000	.150 -1.00
Plant Cleanup	180 - 1,000	200 - 1,200	150 - 800	.050 - .100
TOTAL	2,250 - 8,700	1,920 -11,100	2,560 - 6,760	.355 1,700
AVERAGE	5,500	6,000	4,700	1,025

B. Wasteload Production Rates

Table II-3 illustrates the varying wasteloads generated by different fruits and vegetables. The variety of processes employed by different plants results in the ranges of wasteloads.

The following is a summary of average waste loads produced per equivalent case processed.

	BOD (lb)	SS (lb)	TDS (lb)	Volume (gal)
Prevalent	0.62	0.62	0.50	125
Newer	0.55	0.60	0.47	102

C. Total Wasteload

The following estimates for total wasteload generated in 1963 were derived by using the average wasteload and volume figures given in Section II A under "Prevalent Technology" and assuming the subprocess mix as given in Section I D.

BOD (million lb)	SS (million lb)	TDS (million lb)	Volume (billion gal)
290	325	315	35

D. Gross Wasteload Projection

The following wasteload projections are based on the values provided by the FWPCA and on the trend for most prevalent subprocesses. It is assumed that water requirements and waste production will be reduced as greater recirculation and improved methods and equipment are adopted in the future.

Year	1968	1969	1970	1971	1972	1977
BOD million lb	350	355	360	370	380	415
SS million lb	390	400	410	420	425	470
TDS million lb	380	385	395	495	415	455
Vol. billion gal	48	49	50	51	52	56

E. Seasonal Variation

See Section II E under canning.

III. WASTE REDUCTION PRACTICES

A. Processing Practices

The discussion under canning (see Section III A, p. 40) is also applicable to frozen food processing. Because frozen food plants nationwide are generally in areas of cheaper water supply and generally not connected to municipal sewers, there has not been as much incentive to modify in-plant processes to reduce pollution generated. Extensive study is required to determine where and how process modifications can be made.

B. Treatment Practices

See discussion under canning (Section III B, p.40). A higher percentage of frozen food plants have constructed their own lagoons or spray irrigation disposal facilities because a much lower percentage have access to municipal sewers.

1. Discharge to Municipal Sewerage Systems

The quantity of wastes discharged from the frozen food industry to municipal sewerage systems has been increasing in terms of both volume and percentage. This trend is expected to continue for several reasons: establishment and/or relocation of plants in developed industrialized areas where municipal sewerage systems are available; urban growth encircling frozen food processing plants with subsequent expansion of municipal sewer systems; and increased pressure by regulatory agencies regarding stream pollution. These assumptions are reflected in the following estimate of the percentage of wastes discharged to municipal sewers.

Year	1950	1963	1967	1972	1977	1982
Wastes Discharged to Sewers (%)	20	25	26	30	35	40

C. By-Product Utilization

In the food processing industry, wastes are largely organic and of a highly bio-degradable nature. However, in a few instances, solid wastes have been sold in adjacent agricultural communities. Pea vines, corn husks, and corn cobs have had limited sales for hog or cattle feed. Citrus peel wastes may be pressed for molasses which can be processed, dried, and sold as cattle feed. It has been reported that installation of flash evaporators to produce the molasses has significantly reduced the wasteload discharged.

Due to the low value of these by-products, the primary benefit to the plant at this time is the avoidance of the cost of hauling wastes to a landfill. As the cost of solid waste disposal increases, it is anticipated that new by-products will be developed, but projecting these by-products in terms of wasteloads and volumes would be conjecture.

D. Net Waste Quantities (1963)

The gross waste discharged in 1963 has previously been estimated in Section II A 4 as 290 million lb of BOD, 325 million lb of SS and 315 million lb of TDS. In 1963 it was estimated that 25 percent of the frozen food plant waste was discharged to a municipal system and treated by municipal sewage treatment facilities. Most of the waste discharged to municipal systems was pretreated by in-plant screens or some other means of gross solids separation prior to discharge.

Of that waste which is not discharged into municipal sewers, it is estimated that virtually all is treated by some form of gross solids separation prior to discharge; however, only one-third is subjected to complete secondary treatment. This one-third represents approximately 25 percent of the total waste discharged.

Average pollution reduction efficiency for municipal plants in 1963 is estimated as follows: BOD 75 percent, SS 85 percent, and TDS 14 percent. These removal efficiencies include the pre-treatment given at the food plant prior to discharge into the sewer.

Average pollution reduction for industry owned and operated secondary treatment facilities in 1963 is estimated as follows: BOD - 80 percent, SS - 90 percent, and TDS - 30 percent. The reason behind the higher reduction for industry operated plants is the wide prevalence of spray irrigation and evaporation/percolation ponds which essentially keep 100 percent of the organic waste out of the nation's watercourses.

E. Projected Net Wasteload

The net waste quantities are estimated in Table III-1. These quantities were calculated based on the gross wasteload generated by the plants before any treatment within the plant, the projected reduction efficiencies within the plants, and municipal treatment facilities, and the projected percentage of waste discharged to municipal treatment works.

TABLE III-1

PROJECTED NET WASTELOADS

Year	Waste	Gross produced by plants (million lb)	Removal (%)	Net quantity reaching watercourses (million lb)
1963	BOD	290	39	177
	SS	325	44	182
	TDS	315	11	280
1968	BOD	350	42	206
	SS	390	47	207
	TDS	380	13	331
1969	BOD	355	43	202
	SS	400	48	208
	TDS	385	13	335
1970	BOD	360	44	202
	SS	410	49	209
	TDS	395	14	340
1971	BOD	370	46	200
	SS	420	51	206
	TDS	405	14	348
1972	BOD	380	47	200
	SS	425	52	204
	TDS	415	15	353
1977	BOD	415	55	137
	SS	470	61	183
	TDS	455	17	378

IV. COST INFORMATION

A. Existing Facilities Costs

It is estimated that in 1966 about half of the nation's frozen food processing plants operated and maintained at least some form of gross solids separation facility, such as screens, to pre-treat the waste prior to discharge. An estimated 25 percent of the plants provided further secondary type treatment such as spray irrigation, percolation/evaporation ponds, etc. It is estimated that the 1966 replacement value of industry owned and operated waste treatment facilities was about $5 million, and that the operating and maintenance costs were in the order of $1 million. These estimates exclude the costs of in-plant water conservation, reuse,and reclamation.

It must be noted that the above values are for industry owned and operated waste effluent facilities only. It is estimated that in 1960 approximately 24 percent of the waste was discharged into and treated by municipal systems. Since industry pays taxes and surcharges to support these facilities, the true industry cost exceeds the foregoing amounts. The replacement value of that portion of municipal treatment facilities construction attributable to this industry's waste is estimated to be $20 million. On the same basis, the annual operating and maintenance cost is estimated at $4 million.

The total 1966 waste reduction costs (exclusive of sewage collection system costs such as municipal sewers) are estimated to be:

Facilities replacement value - $25 million
Operation and Maintenance cost - $5 million

B. Processing and Treatment Costs

It is estimated that processing and treatment costs within the frozen food industry lie within the ranges shown for the canning industry in Section IV B pp. 54-65. It has been found that the processing costs in the frozen food industry are very close to those in the canning industry per equivalent unit of production.

TABLE IV-1

SUMMARY OF PRODUCTION AND WASTE TREATMENT COSTS

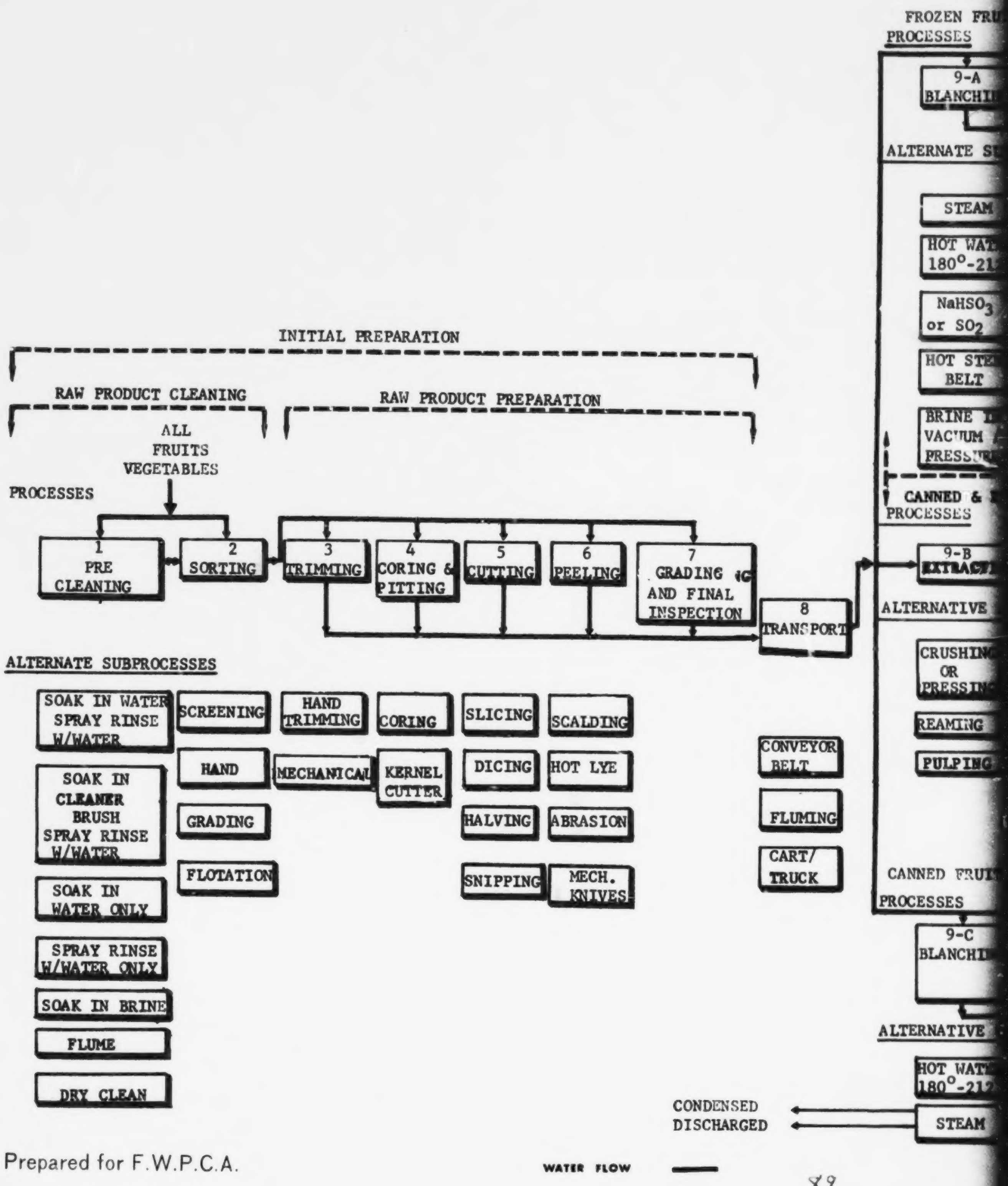
Frozen Fruits and Vegetables

Item	Quantity
Total production	6.75 billion lb
Total value added in manufacture*	$538 million
Average unit value added in manufacture	$0.08/ lb
Estimated replacement value of waste reduction facilities **	$25 million
Annual amortized cost of facilities at 7% and 10 yr life **	$3.5 million
Estimated annual waste reduction operating and maintenance cost **	$5 million
Average industry cost of waste treatment per unit of production	$0.001/lb
Total waste reduction costs as percent of total production cost	1.5 percent

* From the Business and Defense Services Administration, U.S. Department of Commerce, 1967.

** Estimated replacement value, estimated amortization, and estimated annual operating costs include an estimate of the cost of municipal treatment facilities attributable to this industry's wastes.

A


FROZEN FRU
PROCESSES
9-A
BLANCHI
ALTERNATE S
STEAM
HOT WAT
180°-21
NaHSO3
or SO2
HOT STE
BELT
BRINE I
VACUUM
PRESSU
INITIAL PREPARATION
RAW PRODUCT CLEANING
RAW PRODUCT PREPARATION
ALL
FRUITS
VEGETABLES
PROCESSES
1
PRE
CLEANING
2
SORTING
3
TRIMMING
4
CORING &
PITTING
5
CUTTING
6
PEELING
7
GRADING
AND FINAL
INSPECTION
8
TRANSPORT
CANNED &
PROCESSES
9-B
EXTRACT
ALTERNATIVE
CRUSHIN
OR
PRESSIN
REAMING
PULPING
ALTERNATE SUBPROCESSES
SOAK IN WATER
SPRAY RINSE
W/WATER
SOAK IN
CLEANER
BRUSH
SPRAY RINSE
W/WATER
SOAK IN
WATER ONLY
SPRAY RINSE
W/WATER ONLY
SOAK IN BRINE
FLUME
DRY CLEAN
SCREENING
HAND
GRADING
FLOTATION
HAND
TRIMMING
MECHANICAL
CORING
KERNEL
CUTTER
SLICING
DICING
HALVING
SNIPPING
SCALDING
HOT LYE
ABRASION
MECH.
KNIVES
CONVEYOR
BELT
FLUMING
CART/
TRUCK
CANNED FRUI
PROCESSES
9-C
BLANCHI
ALTERNATIVE
HOT WAT
180°-21
STEAM
CONDENSED
DISCHARGED
WATER FLOW

Prepared for F.W.P.C.A.

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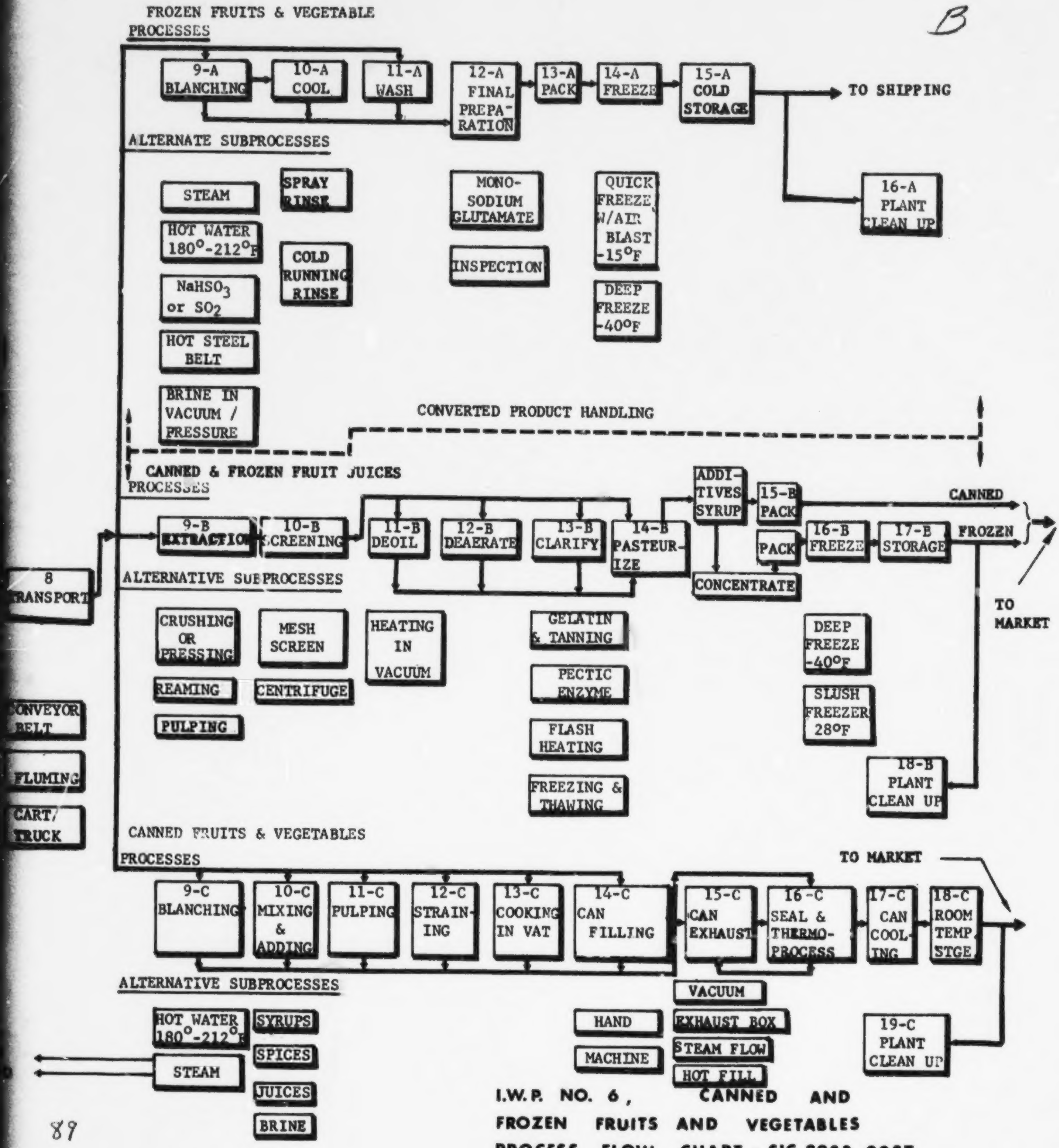
B


FROZEN FRUITS & VEGETABLE PROCESSES
9-A BLANCHING
10-A COOL
11-A WASH
12-A FINAL PREPARATION
13-A PACK
14-A FREEZE
15-A COLD STORAGE
TO SHIPPING
ALTERNATE SUBPROCESSES
STEAM
HOT WATER 180°-212°F
NaHSO3 or SO2
HOT STEEL BELT
BRINE IN VACUUM / PRESSURE
SPRAY RINSE
COLD RUNNING RINSE
MONO-SODIUM GLUTAMATE
INSPECTION
QUICK FREEZE W/AIR BLAST -15°F
DEEP FREEZE -40°F
16-A PLANT CLEAN UP
CONVERTED PRODUCT HANDLING
CANNED & FROZEN FRUIT JUICES PROCESSES
8 TRANSPORT
9-B EXTRACTION
10-B SCREENING
11-B DEOIL
12-B DEAERATE
13-B CLARIFY
14-B PASTEURIZE
ADDITIVES SYRUP
15-B PACK
PACK
CONCENTRATE
16-B FREEZE
17-B STORAGE
CANNED
FROZEN
TO MARKET
ALTERNATIVE SUBPROCESSES
CRUSHING OR PRESSING
REAMING
PULPING
MESH SCREEN
CENTRIFUGE
HEATING IN VACUUM
GELATIN & TANNING
PECTIC ENZYME
FLASH HEATING
FREEZING & THAWING
DEEP FREEZE -40°F
SLUSH FREEZER 28°F
18-B PLANT CLEAN UP
CONVEYOR BELT
FLUMING
CART/ TRUCK
CANNED FRUITS & VEGETABLES PROCESSES
TO MARKET
9-C BLANCHING
10-C MIXING & ADDING
11-C PULPING
12-C STRAINING
13-C COOKING IN VAT
14-C CAN FILLING
15-C CAN EXHAUST
16-C SEAL & THERMO-PROCESS
17-C CAN COOLING
18-C ROOM TEMP STGE
ALTERNATIVE SUBPROCESSES
HOT WATER 180°-212°F
STEAM
SYRUPS
SPICES
JUICES
BRINE
HAND
MACHINE
VACUUM
EXHAUST BOX
STEAM FLOW
HOT FILL
19-C PLANT CLEAN UP

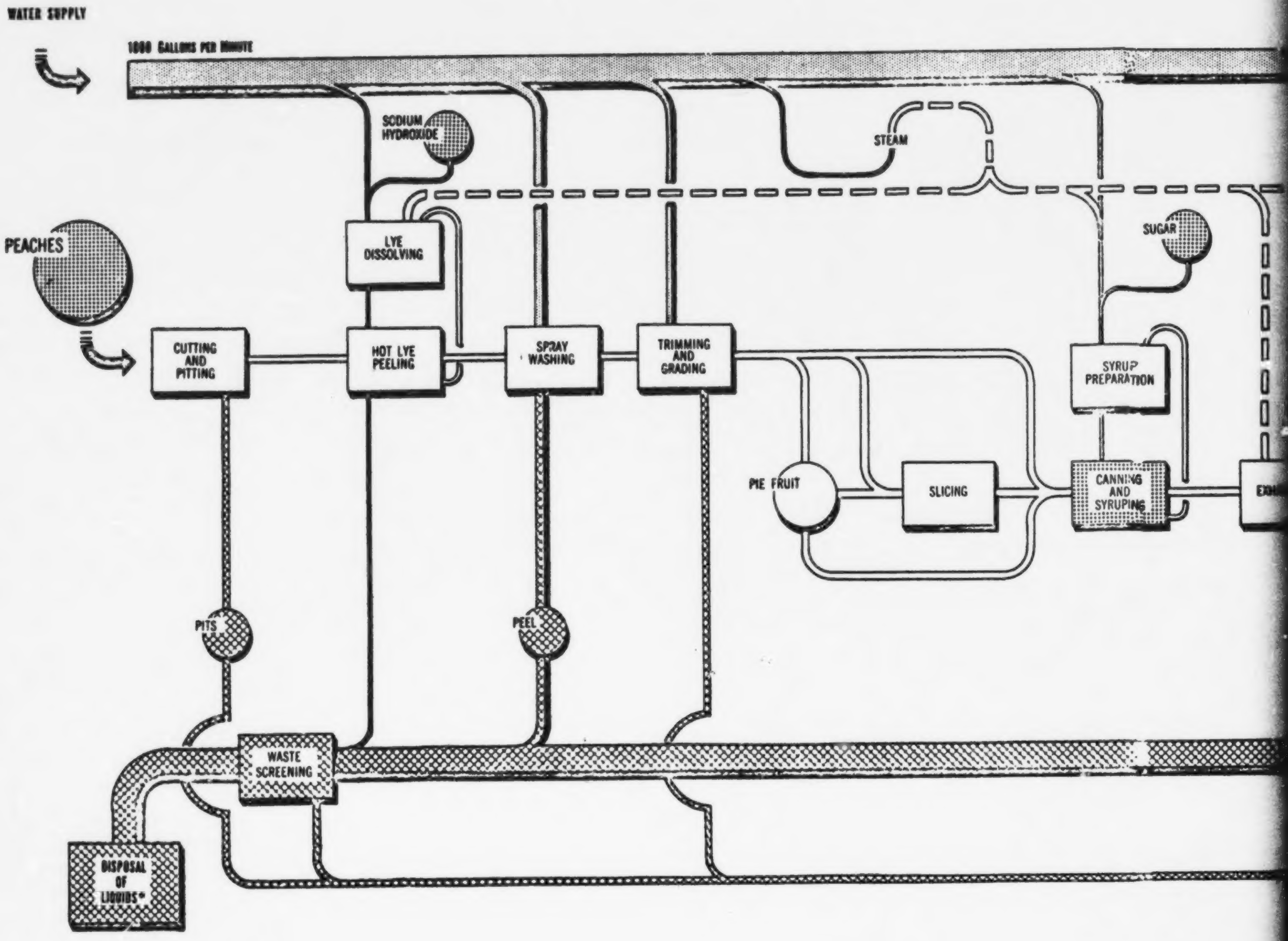
I.W.P. NO. 6, CANNED AND FROZEN FRUITS AND VEGETABLES PROCESS FLOW CHART - SIC 2033, 2037

PLATE 1

A

WATER USE AND SOURCES OF WASTES IN A T

PROCESSING RATE 25 TONS PEACHES PER HOUR; 35 40 DAY SEAS


WATER SUPPLY
1000 GALLONS PER MINUTE
SODIUM HYDROXIDE
STEAM
PEACHES
LYE DISSOLVING
SUGAR
CUTTING AND PITTING
HOT LYE PEELING
SPRAY WASHING
TRIMMING AND GRADING
SYRUP PREPARATION
PIE FRUIT
SLICING
CANNING AND SYRUPING
EXH
PITS
PEEL
WASTE SCREENING
DISPOSAL OF LIQUIDS*

*CROP IRRIGATION; PONDING ON LAND; OR DISPOSAL BY DILUTION TO WATERCOURSES

**SUGAR RECOVERY, LAND FERTILIZING, STOCK FEED, OR FILL AND COVER

● RAW M

▨ OPERAT

Prepared for F.W.P.C.A.

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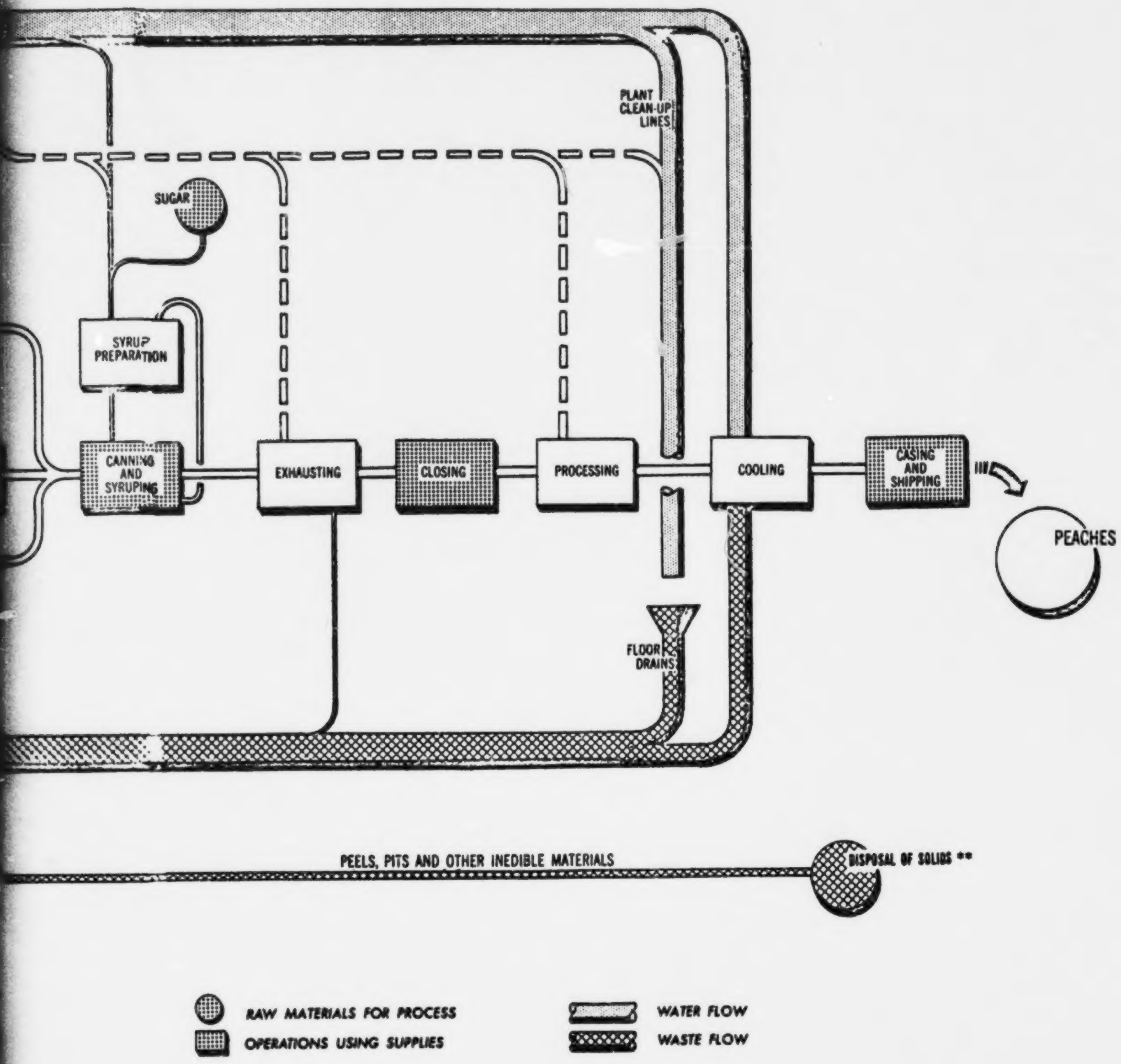
13

STES IN A TYPICAL PEACH CANNERY

HOUR; 35 40 DAY SEASON; 2 SHIFTS PER DAY


PLANT CLEAN-UP LINES
SUGAR
SYRUP PREPARATION
CANNING AND SYRUPING
EXHAUSTING
CLOSING
PROCESSING
COOLING
CASING AND SHIPPING
PEACHES
FLOOR DRAINS
PEELS, PITS AND OTHER INEDIBLE MATERIALS
DISPOSAL OF SOLIDS **
RAW MATERIALS FOR PROCESS
OPERATIONS USING SUPPLIES
WATER FLOW
WASTE FLOW

90

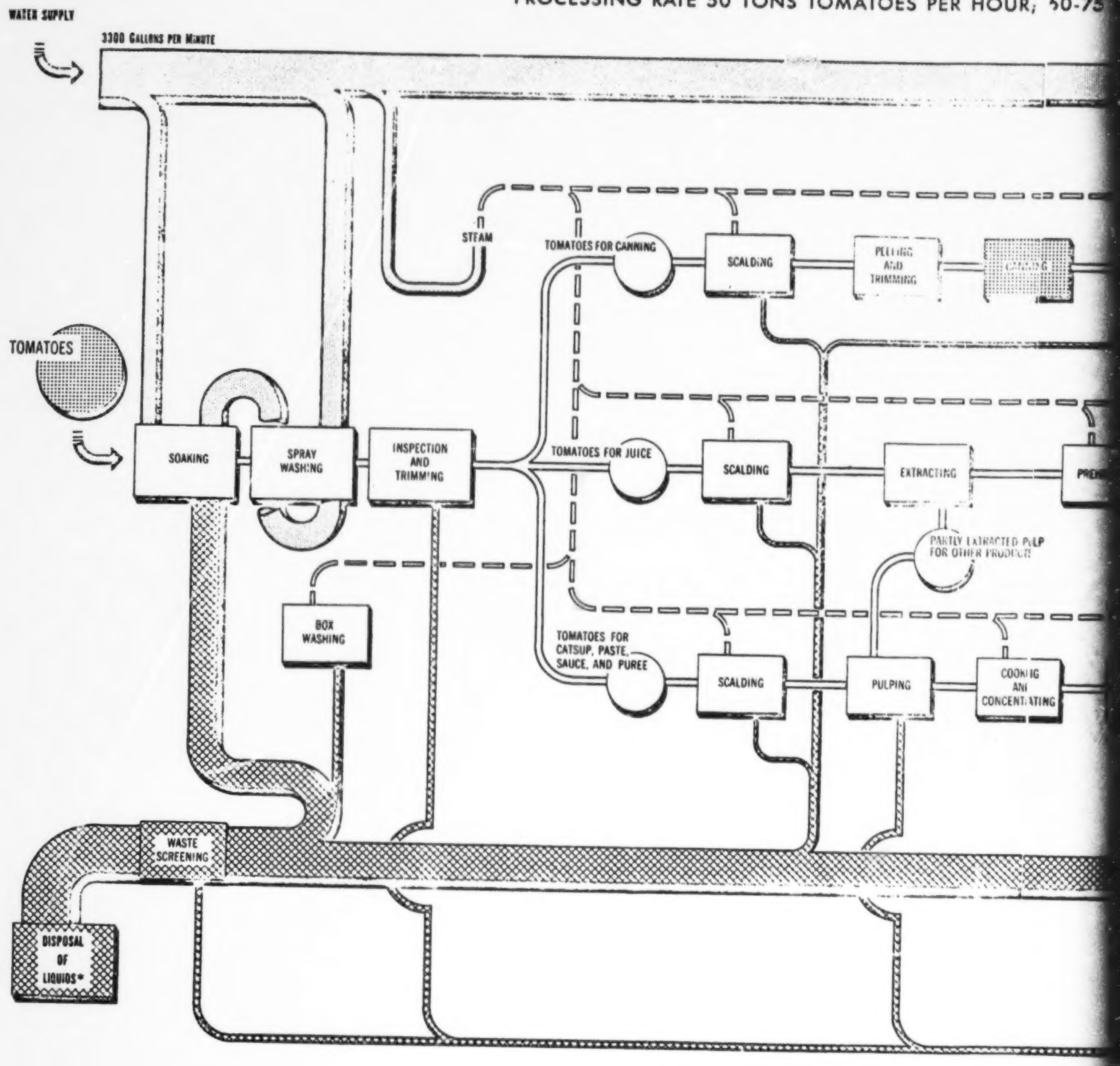
I.W.P. NO. 6, CANNED AND
FROZEN FRUITS AND VEGETABLES
PROCESS FLOW CHART - SIC 2033, 2037

PLATE 2

A

WATER USE AND SOURCES OF WASTES IN

PROCESSING RATE 50 TONS TOMATOES PER HOUR; 60-75


WATER SUPPLY
3300 GALLONS PER MINUTE
STEAM
TOMATOES FOR CANNING
SCALDING
PEELING AND TRIMMING
CANNING
TOMATOES
SOAKING
SPRAY WASHING
INSPECTION AND TRIMMING
TOMATOES FOR JUICE
SCALDING
EXTRACTING
PREH
PARTLY EXTRACTED PULP FOR OTHER PRODUCTS
BOX WASHING
TOMATOES FOR CATSUP, PASTE, SAUCE, AND PUREE
SCALDING
PULPING
COOKING AND CONCENTRATING
WASTE SCREENING
DISPOSAL OF LIQUIDS*

* CROP IRRIGATION, PONDING ON LAND, OR DISPOSAL BY DILUTION TO WATERCOURSES

** LAND FERTILIZING, STOCK FEED, OR FILL AND COVER

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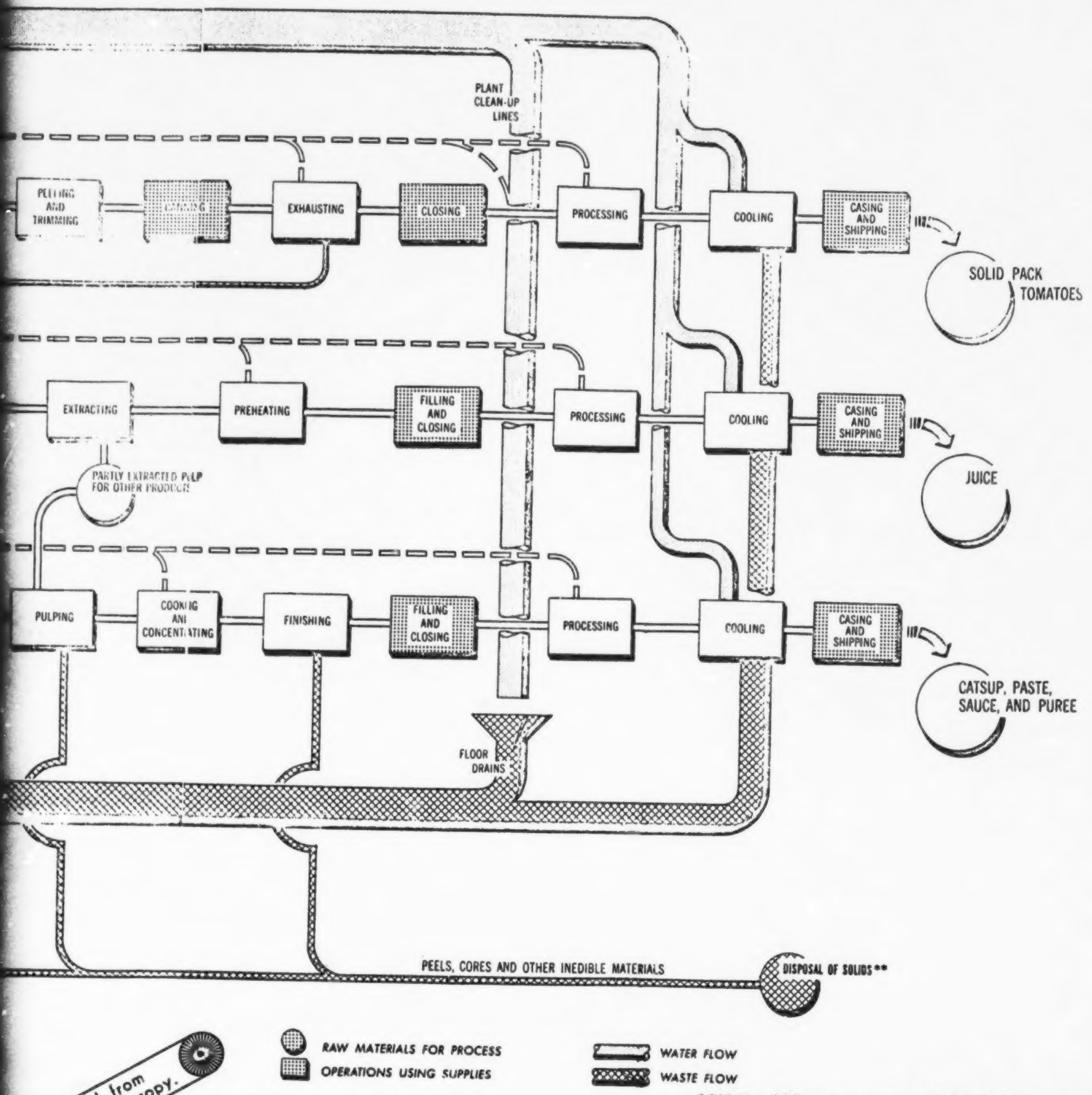
B

F WASTES IN A TYPICAL TOMATO CANNERY

ATOES PER HOUR; 60-75 DAY SEASON; 2 SHIFTS PER DAY


PLANT CLEAN-UP LINES
PEELING AND TRIMMING
CANNING
EXHAUSTING
CLOSING
PROCESSING
COOLING
CASING AND SHIPPING
SOLID PACK TOMATOES
EXTRACTING
PREHEATING
FILLING AND CLOSING
PROCESSING
COOLING
CASING AND SHIPPING
JUICE
PARTLY EXTRACTED PULP FOR OTHER PRODUCTS
PULPING
COOKING AND CONCENTRATING
FINISHING
FILLING AND CLOSING
PROCESSING
COOLING
CASING AND SHIPPING
CATSUP, PASTE, SAUCE, AND PUREE
FLOOR DRAINS
PEELS, CORES AND OTHER INEDIBLE MATERIALS
DISPOSAL OF SOLIDS**
RAW MATERIALS FOR PROCESS
OPERATIONS USING SUPPLIES
WATER FLOW
WASTE FLOW

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I.W.P. NO. 6, CANNED AND FROZEN FRUITS AND VEGETABLES PROCESS FLOW CHART - SIC 2033, 2037

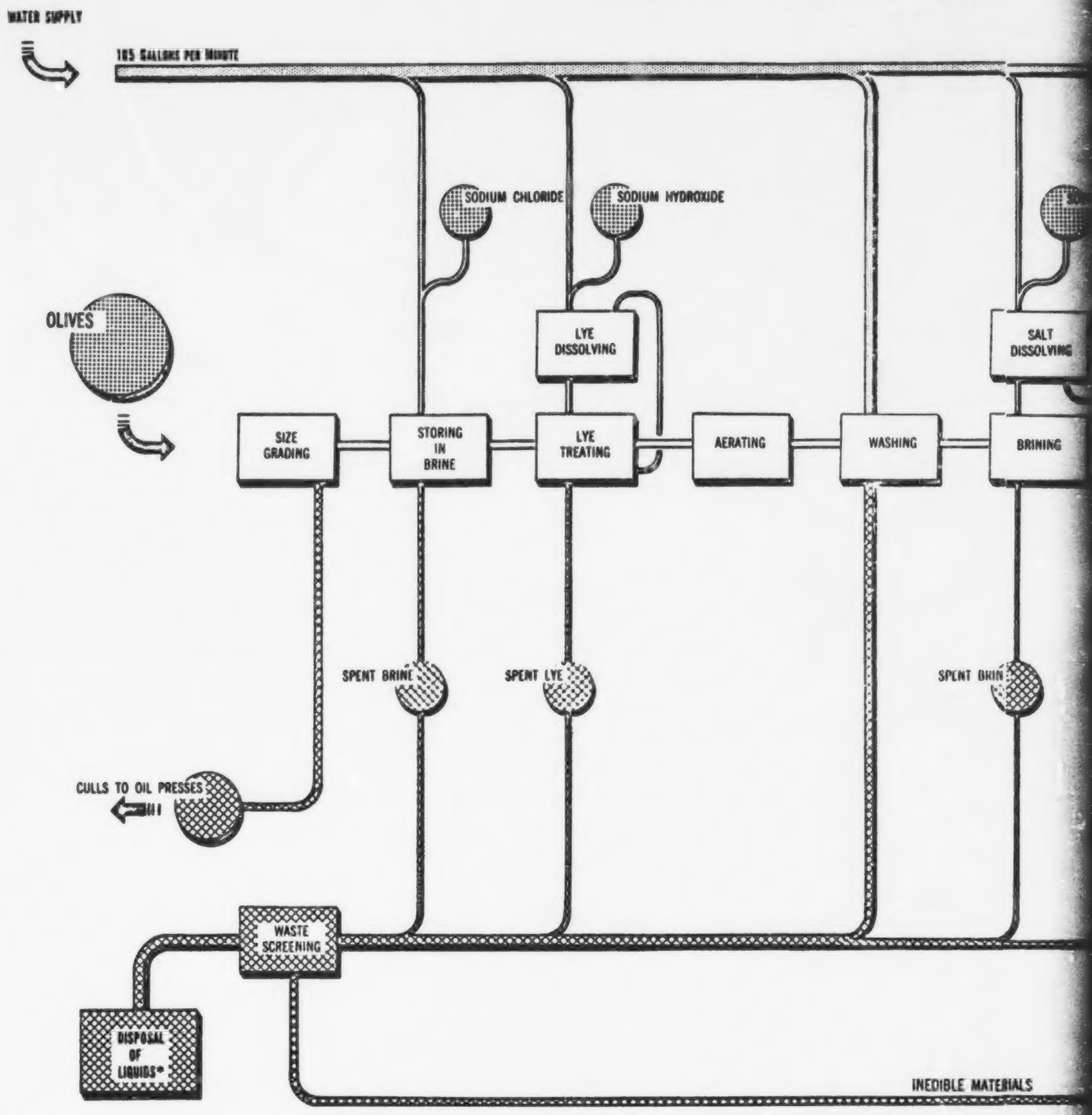
PLATE 3

91

A

WATER USE AND SOURCES OF WAST

PROCESSING RATE 1 TON OLIVES PER HOUR,


WATER SUPPLY
185 GALLONS PER MINUTE
SODIUM CHLORIDE
SODIUM HYDROXIDE
OLIVES
LYE DISSOLVING
SALT DISSOLVING
SIZE GRADING
STORING IN BRINE
LYE TREATING
AERATING
WASHING
BRINING
SPENT BRINE
SPENT LYE
SPENT BRINE
CULLS TO OIL PRESSES
WASTE SCREENING
DISPOSAL OF LIQUIDS*
INEDIBLE MATERIALS

*PONDING ON LAND, OR DISPOSAL BY DILUTION TO WATERCOURSES

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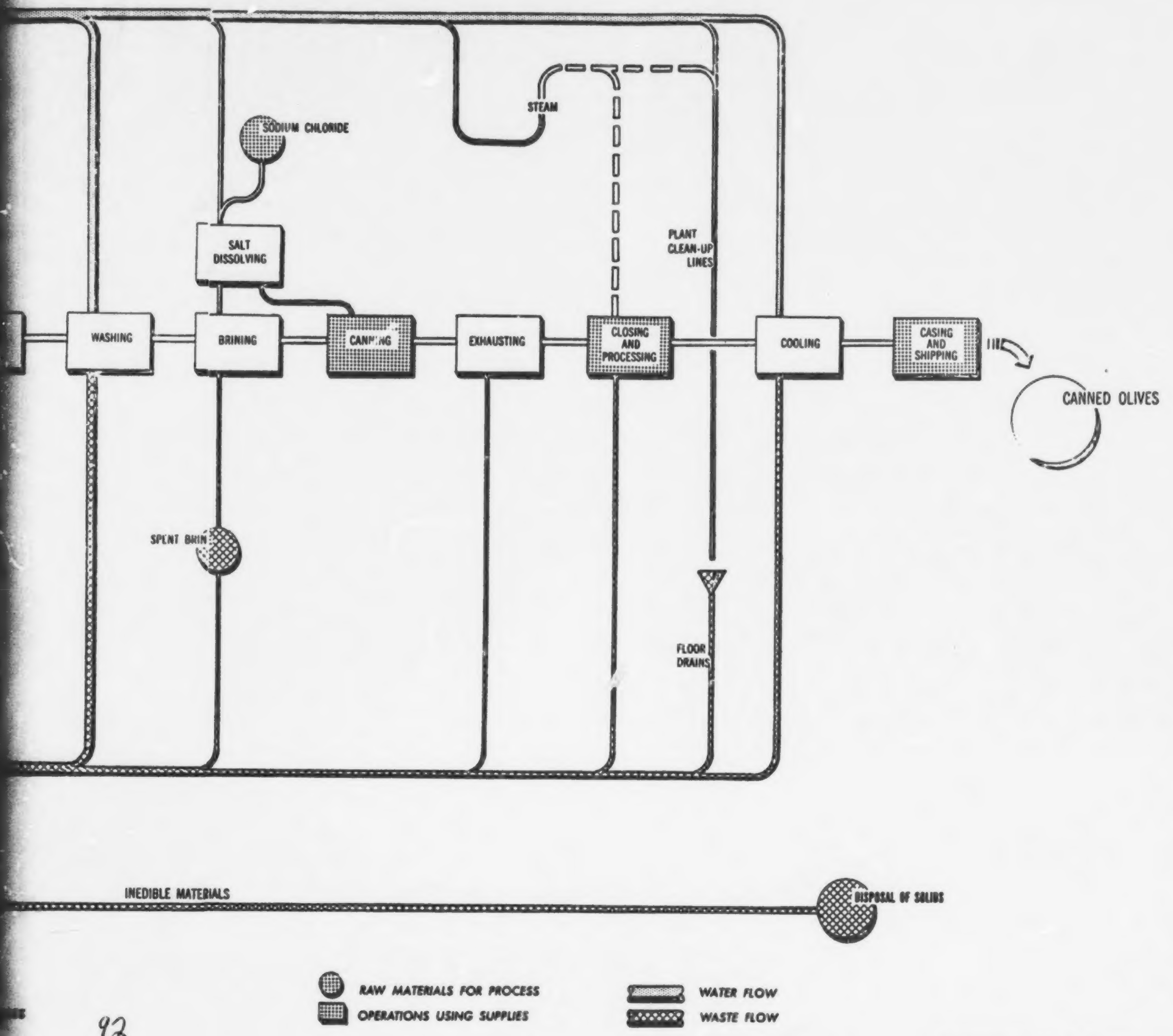
ES OF WASTES IN A TYPICAL OLIVE CANNERY

B

1 TON OLIVES PER HOUR; 6 MONTH SEASON; 1 SHIFT PER DAY


STEAM
SODIUM CHLORIDE
SALT DISSOLVING
PLANT CLEAN-UP LINES
WASHING
BRINING
CANNING
EXHAUSTING
CLOSING AND PROCESSING
COOLING
CASING AND SHIPPING
CANNED OLIVES
SPENT BRIN
FLOOR DRAINS
INEDIBLE MATERIALS
DISPOSAL OF SOLIDS
RAW MATERIALS FOR PROCESS
OPERATIONS USING SUPPLIES
WATER FLOW
WASTE FLOW

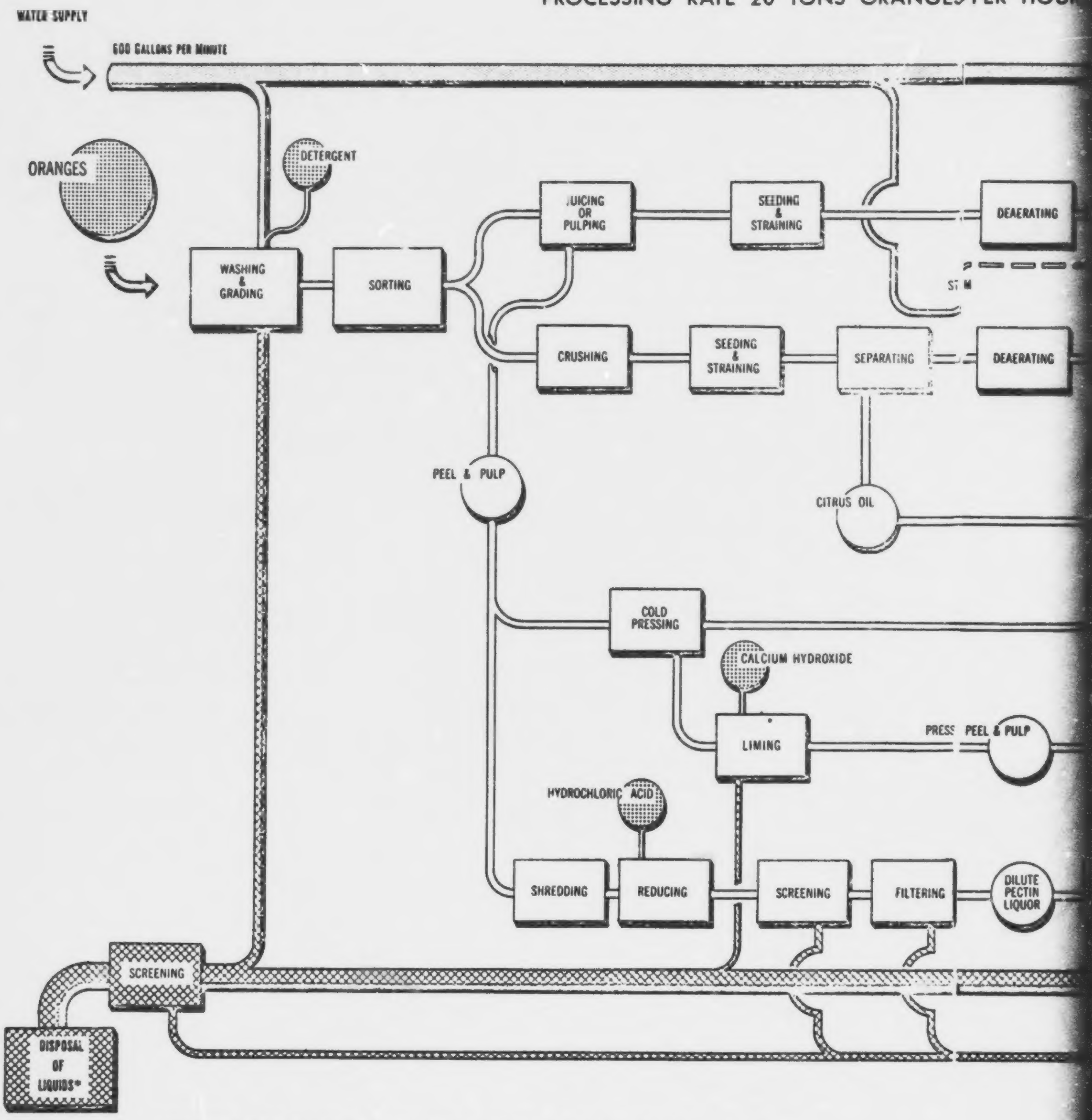
I.W.P. NO. 6, CANNED AND FROZEN FRUITS AND VEGETABLES PROCESS FLOW CHART - SIC 2033, 2037

PLATE 4

A

WATER USE AND SOURCES OF WASTE

PROCESSING RATE 20 TONS ORANGES PER HOUR



WATER SUPPLY
600 GALLONS PER MINUTE
ORANGES
DETERGENT
WASHING & GRADING
SORTING
JUICING OR PULPING
SEEDING & STRAINING
DEAERATING
ST M
CRUSHING
SEEDING & STRAINING
SEPARATING
DEAERATING
PEEL & PULP
CITRUS OIL
COLD PRESSING
CALCIUM HYDROXIDE
LIMING
PRESS PEEL & PULP
HYDROCHLORIC ACID
SHREDDING
REDUCING
SCREENING
FILTERING
DILUTE PECTIN LIQUOR
SCREENING
DISPOSAL OF LIQUIDS*

* CROP IRRIGATION, PONDING ON LAND, OR DISPOSAL BY DILUTION TO WATERCOURSES

** LAND FERTILIZING

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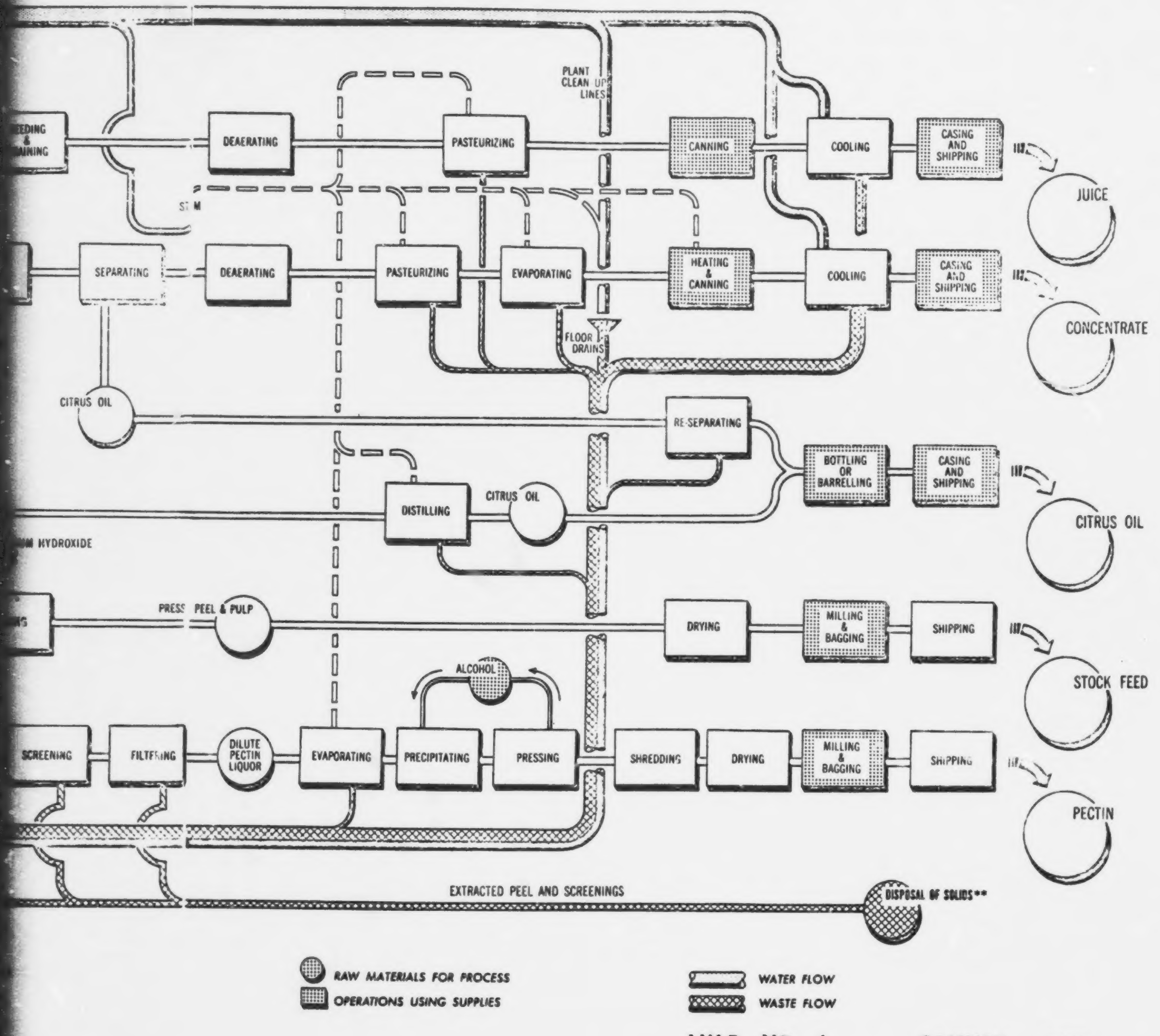
9/67

93

B

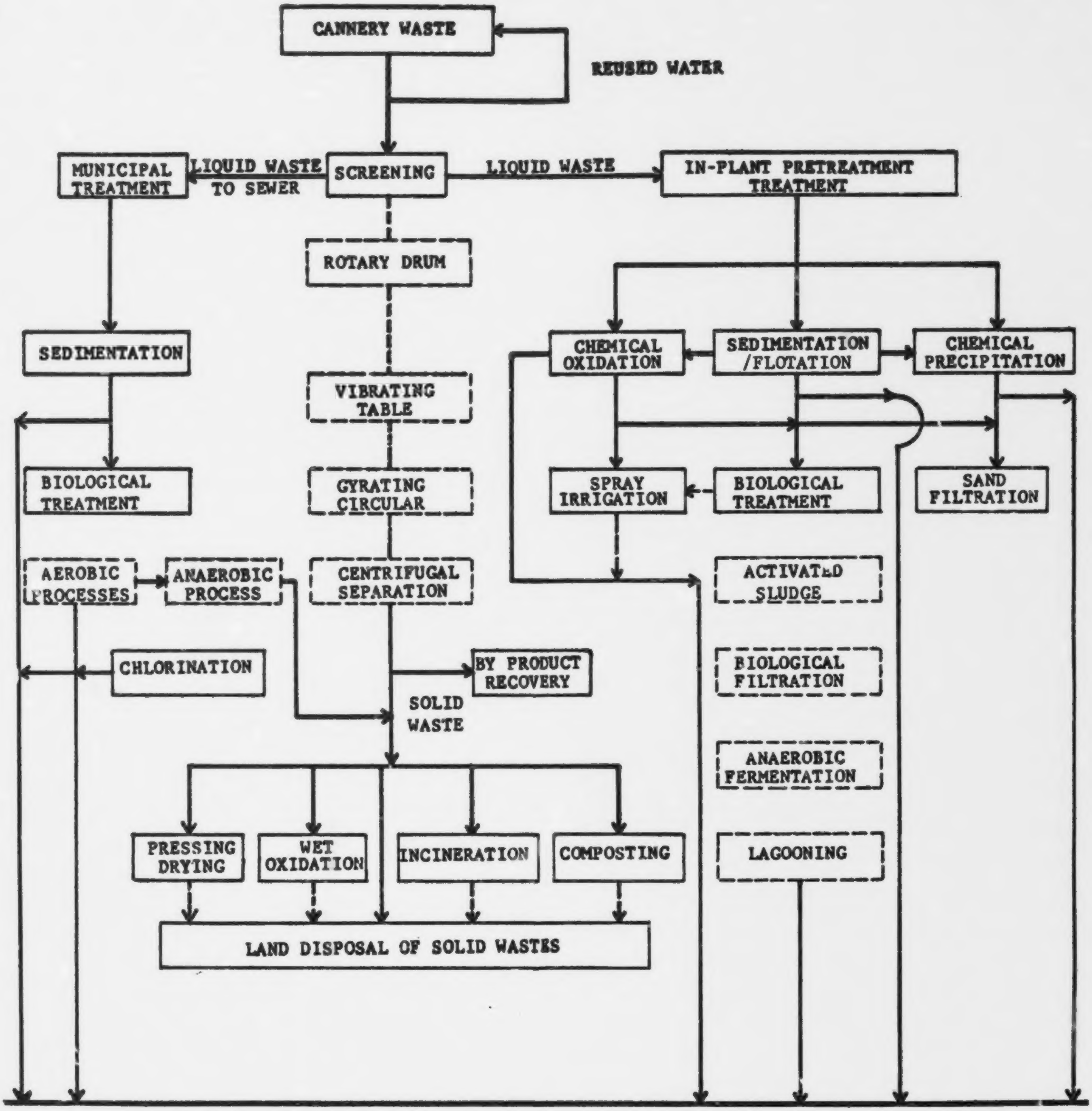
CES OF WASTES IN A TYPICAL CITRUS CANNERY

0 TONS ORANGES PER HOUR; 8 MONTHS SEASON; 2 SHIFTS PER DAY


EEDING & AINING
DEAERATING
PASTEURIZING
PLANT CLEAN UP LINES
CANNING
COOLING
CASING AND SHIPPING
JUICE
STM
SEPARATING
DEAERATING
PASTEURIZING
EVAPORATING
HEATING & CANNING
COOLING
CASING AND SHIPPING
CONCENTRATE
FLOOR DRAINS
CITRUS OIL
RE-SEPARATING
BOTTLING OR BARRELLING
CASING AND SHIPPING
DISTILLING
CITRUS OIL
CITRUS OIL
M HYDROXIDE
NGS
PRESS PEEL & PULP
DRYING
MILLING & BAGGING
SHIPPING
STOCK FEED
ALCOHOL
SCREENING
FILTERING
DILUTE PECTIN LIQUOR
EVAPORATING
PRECIPITATING
PRESSING
SHREDDING
DRYING
MILLING & BAGGING
SHIPPING
PECTIN
EXTRACTED PEEL AND SCREENINGS
DISPOSAL OF SOLIDS**
RAW MATERIALS FOR PROCESS
OPERATIONS USING SUPPLIES
WATER FLOW
WASTE FLOW

I.W.P. NO. 6, CANNED AND
FROZEN FRUITS AND VEGETABLES
PROCESS FLOW CHART - SIC 2033, 2037

PLATE 5


CANNERY WASTE
REUSED WATER
MUNICIPAL TREATMENT
LIQUID WASTE TO SEWER
SCREENING
LIQUID WASTE
IN-PLANT PRETREATMENT TREATMENT
ROTARY DRUM
SEDIMENTATION
VIBRATING TABLE
CHEMICAL OXIDATION
SEDIMENTATION /FLOTATION
CHEMICAL PRECIPITATION
BIOLOGICAL TREATMENT
GYRATING CIRCULAR
SPRAY IRRIGATION
BIOLOGICAL TREATMENT
SAND FILTRATION
AEROBIC PROCESSES
ANAEROBIC PROCESS
CENTRIFUGAL SEPARATION
ACTIVATED SLUDGE
CHLORINATION
BY PRODUCT RECOVERY
BIOLOGICAL FILTRATION
SOLID WASTE
ANAEROBIC FERMENTATION
PRESSING DRYING
WET OXIDATION
INCINERATION
COMPOSTING
LAGOONING
LAND DISPOSAL OF SOLID WASTES

Prepared for F.W.P.C.A.

9/67

I.W.P. NO. 6, CANNED AND FROZEN FRUITS AND VEGETABLES WASTE TREATMENT FLOW CHART-SIC 2033, 2037

PLATE 6

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APPENDIX I.

GLOSSARY

Definitions

Activated Sludge - a process for treating liquid waste by aeration and recirculation of biologically active sludge.

Aeration - the act of supplying with oxygen.

Aerobic - living or active in the presence of oxygen.

Anaerboic - living or active in the absence of oxygen.

Bio-degradation - reduction to a lower form by means of living organisms.

Carbohydrase - an enzyme which hydrolyzes carbohydrates.

Blanch - to whiten by removing the skin, as by scalding.

Blow-down - process water removed from a recirculating system.

Brine - a strong activity solution of common salt, NaCl.

Catalase - an enzyme that catalyzes the decomposition of hydrogen peroxide into water and oxygen.

Causticizing - treating with a corrosive chemical capable of eating or destroying.

Countercurrent - flow of wash water in opposition to flow of product so that the product encounters increasingly cleaner water.

Coagulation - the change from a liquid to a thickened, curd-like state.

Cull - an article rejected for inferiority or worthlessness.

Effluent - polluted water discharged from a process.

Enzyme - any of a class of complex organic substances that accelerate specific transformations of material, as the digestion of foods.

Equalization - the process of combining two or more dissimilar wastes to produce a uniform composite.

Fermentation - the catalytic decomposition of a complex compound into simpler ones.

Glutamate - a salt or ester of glutamac acid ($C_5H_9NO_4$).

Lagooning - a liquid waste treatment process of holding the waste in shallow ponds for a period of several hours to allow absorption of oxygen.

Leach - to subject to the action of percolating water or other liquid in order to separate soluble components.

Lime - a caustic white solid, CaO, which forms slaked lime, $CO(OH)_2$ when combined with water.

Lye - any strong alkaline solution, especially potassium carbonate.

Make-up - water used to supplement process water due to system losses.

Neutralize - to adjust the pH of a solution to seven (neutral) by the addition of an acid or a base.

Pectic acid - any of various water insoluble substances formed by hydrolyzing the methyl ester groups of pectins.

Pectin - any of certain water-soluble substances in plant tissues, yielding jelly which is the basis of fruit jellies.

Peroxidase - an enzyme that catalyzes the oxidation of various substances by peroxides.

Potable - drinkable.

Precipitate - to cause to separate from solution or suspension.

Process - a series of actions or operations definitely conducting to an end; continuous operation or treatment, especially as in manufacture.

Proteinase - an enzyme which hydrolyzes proteins.

Raw Ton - one ton of unprocessed material.

Screening - separation of solid material from liquid waste by passing the waste through screens.

Sedimentation - the act or process of settling matter to the bottom of a liquid.

Sludge - the precipitated solid matter produced by water and sewage treatment process.

Subprocess - an alternate method of conducting a process.

Trickling Filtration - a liquid waste treatment process involving trickling the waste through a bed of stone or other inert material.

Conversion Factors

Can Sizes

1 No. 10 can equals 7 No. 303 (1 lb) cans

1 No. 10 can equals 5 No. 2 (1 lb 4 oz) cans

1 No. 10 can equals 4 No. 2 1/2 (1 lb 13 oz) cans

1 No. 10 can equals 2 No. 3 cylinder (46-50 oz) cans

A standard case consists of 24 - No. 303 cans at 1 lb each, a total of 24 lb.

1 lb of frozen fruits or vegetables is equivalent to approximately 1.50 lb of canned fruits or vegetables.

APPENDIX II

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